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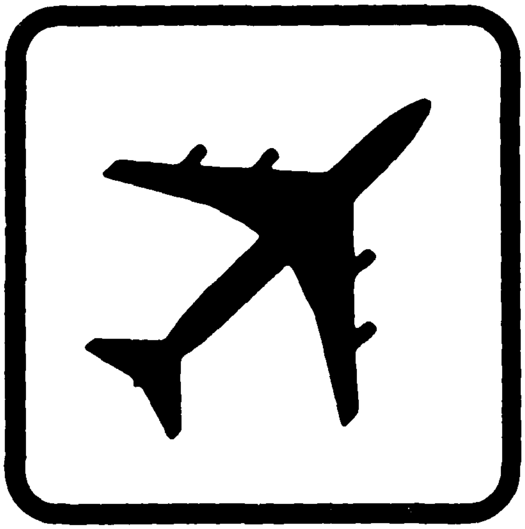

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November 24 & 25, 1980

Presented at the
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Kendall Square
Cambridge, Massachusetts

UNITED STATES DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

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PRESENTED AT: TRANSPORTATION SYSTEMS CENTER
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DATE: NOVEMBER 24, 1980

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FOREWORD

This document is a verbatum transcript of the proceedings of the DOT/FAA Human Factors Workshop on Aviation held at the Transportation Systems Center in Cambridge, Massachusetts on November 24-25, 1980. No editorial corrections have been made. Additional workshops/symposiums are scheduled to address human factors safety issues. On January 16, the Second FAA Commuter Airline Symposium will be devoted to human factors. In addition, another workshop is planned to be held at the Transportation Systems Center during March 1981. Proceedings will remain open until 60 days after the March 1981 workshop and then will be published in their entirety.

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SESSION TWO - PILOTS' PERSPECTIVES ON HUMAN FACTORS

PROCEEDINGS

MR. ANDERSEN: I'd like to introduce myself, my name is Jim Andersen. I'm the Director of the Air and Marine Systems here at TSC and I'll be your workshop moderator for the next two days. I'd like to introduce the Center Director Dr. James Costantino.

DR. COSTANTINO: Thank you very much, Jim. Good morning, and welcome to the Transportation Systems Center and to this human factors workshop in aviation. I want to extend a special welcome to our guests from the international aviation community who are here with use today. This two-day meeting is sponsored by the Federal Aviation Administration and is the first in a planned series to address aviation human factors safety issues. When we speak of aviation human factors in this workshop, we will be concerned with all aspects of human behavior which are considered in the design, operation and maintenance of aviation man machine systems. Basically it is the aim of human factors to make certain that technology remains our service, not our master.

In this first workshop we hope to establish a common frame of understanding as to ongoing efforts in the human factors area and to start gathering information for the development of a human factors research agenda for the future.

It might be helpful in the beginning for those of you who are not familiar with the Transportation Systems Center, to give you a very brief overview of our role here in Cambridge, especially as it pertains to the FAA.

This Center is DOT's research analysis and development facility for major programs in air, rail motor vehicle, pipeline and marine transportation. With an annual budget here some $70 million and a staff of approximately 1,000 federal employees and on-site support contractors, we carry out major R&D programs for the Office of the Secretary and all of the administrations within the Department of Transportation. About 50 percent of our research dollars go out to private industry and universities throughout the country. To a lesser degree we also perform research for other government agencies, such as the Department of Energy, Environmental Protection Agency, Civil Aeronautics Board, and so forth. We also provide research assistance to state and local governments and private industry with engineering, economic and planning data in their own transportation programs.

We currently have on board here at TSC approximately 200 research programs. We also have a faculty fellows program where we have faculty members from various universities throughout the country and indeed throughout the world who are here and spend their one or two year sabbaticals with us.

We also have an interchange program with foreign countries, where we have researchers from countries such as Germany, Poland, Italy, Japan and so forth who spend a year with us and we send some of our researchers overseas to spend time with them.

Since its opening in 1970, TSC has supported programs in all elements of the FAA. This support has been funded at over 100 million dollars. It is ranged in scope from participation and short term technical proposal evaluations to longer term technical management of some major R&D programs. One of our earliest significant outputs was the airport information retrieval system developed in the central flow facility in 1972 and the ATCRBS open array antenna in 1976.

Our most recent contribution was the development of a complete technical data package for the airport surface detection radar ASDE-3 delivered in December of 1979. Other projects of the nearly 100 which the center has performed for the FAA in the past ten years include the development of a small community airport microwave landing system, aviation forecasting, aircraft noise measurements, the high altitude pollution program, wake vortex avoidance systems as well as several human factors efforts such as consolidated tower cab design studies and controller performance studies. We also conducted the study of advanced air traffic management systems for the Office of the Secretary several years ago.

Currently we are providing major support to the FAA in the design and the development of an aviation safety analysis system for the Office of Aviation Safety and have an important continuing responsibility in the flight service automation programs for the Office of Engineering and Development.

We're doing research in aircraft tires and structures in our laboratories where the research in some DC-10 tires is currently going on and available for your inspections today.

Explosive detection techniques in systems, aviation weather systems design, studies in navigation, oceanic communications and integrated flow management.

Our involvement here at TSC and human factors research has spanned the more than ten years the center was established. Under the direction of Dr. Harold Bishop, Chief of the Behavioral Systems Branch over 60 projects addressing a wide spectrum of human factors problems have been conducted here or in conjunction with industry and universities and they've included every transportation mode. For example we've assessed information display alternatives for pilots, controllers and paratransit dispatchers. We've developed a system, an equipment design criteria for passenger safety, security, and acceptability in ground systems. And we've evaluated factors affecting safety in rail operations. The Coast Guard for the past seven years has sponsored research programs at TSC and human factors which addresses broad areas of vessel traffic services known as VTS. VTS centers are located at congested port areas such as San Francisco, New Orleans, Seattle and Valdez, Alaska.

We have conducted detailed analyses of watch stander performance, designed a program for selection and training of such watch standers, and provide human factors specifications for a next generation VTS processing display subsystem.

We are currently preparing recommendations for an improved VTS operating procedures.

We are all aware of the critical role the human factors element plays in assuring the safety, reliability and efficiency of the world's air transportation system. Pilots, controllers, maintenance and inspection personnel are part of this system and our aviation safety record is tangible evidence of what an outstanding job they do. But in a continuing quest for improvement, questions arise regarding the human elements particularly the effects of inevitable human errors on systems safety and reliability. A large number of activities are currently underway within the FAA, other government elements, industry and academia which are present or potential contributors to a better understanding of these questions. More needs to be done, obviously. And that is why you've been invited to this workshop here today.

Each segment of aviation, government, pilots, aircraft manufacturers and operators is represented here today by a panel and a moderator.

Through the public discussions and dialogues which will take place here today and tomorrow, the FAA is taking one of many steps toward a closer coordination of the many factors activities -- many human factors activities -- and the development of a better integrated aviation human factors program.

Our discussion today, for your information, is being recorded and we plan to develop and issue a synopsis of the proceedings here.

It's a pleasure to have many of you join us here at TSC for this important conference, and it's now my pleasure to introduce to you the Administrator of the Federal Aviation Administration, Langhorne Bond.

MR. BOND: Thank you very much, that you Dr. Costantino. We are guests in your distinguished institution today. We are very grateful for your hospitality now and the help that you provide us throughout the year.

As the machines that we use in aviation have become better and better, so has our safety record become better and better. Today's equipment is so good and so reliable, that its occasional failure are a relatively minor factor in accident rates. We made the machines and we can generally figure out what went wrong when they break. And so we can learn how to keep that particular failure from happening again. But we did not make the men and women who run the machinery, and we don't yet have any clear notion about how to make them less likely to fail.

When I first went to find out what the FAA was doing to study this problem, the human factor, I felt a little bit like General DeGaulle. The General once said of his country, how can you possibly govern a country that has 400 kinds of cheese. That comment should be extrapolated to Washington interest groups, by the way. That's going to be in my book to the next administrator.

I learned that we had at least 43 different programs throughout the FAA dealing with various human factors problems. To bring all these together, and to get them working along the same track, last year I set up a task force on human factors in the National Aviation System. And today we're meeting here to seek the advice of industry, the military, the user groups and the international aviation community. What we're looking for is not answers, not yet. First we need to know what questions to ask. And then we can set out

together on the search for answers. So this is then just a beginning. If we can come to an understanding of why human beings make mistakes when dealing with complex machinery, we stand a chance of eliminating the causes of those mistakes and of avoiding them next time. To reach that understanding, we need a data base that we lack today. Without data, we will find ourselves operating in a vacuum, when it comes to drafting regulations, proving designs, training the people who maintain them, and those who fly airplanes. I hope this workshop will help us find out what data we need and in what areas, and what to do with it once we gather it.

Let me list a few of the areas in which I hope that you can help us. What is the effect of workload on error? We know that it can be so light as to cause inattention; and so heavy as to cause failure. Where is the optimal point between these extremes? I was astounded in looking into one of our own FAA operational programs, for example, to find in the field of system errors, that a very high proportion of our system errors in the air traffic control system occurred under very light conditions of work. What is the effect of fatigue? How can we measure it, and how can we prevent it? What is the role of circadian rhythm in causing fatigue or accidents, or both? Is the likelihood of confusion or error built into some of our machinery? In what cases has design induced errors? And how can we correct them? Is it easy enough to find out when our machines need servicing and repair? And are critical devices accessible for repair? Is our training adequate for managers and supervisors, as well as for pilots, controllers and maintenance personnel?

In a largely automated system, how do we keep attention focussed on the job at hand? We do not want to pay for gains and productivity by increasing the chance that people will become so complacent that they lose the sharp edge, the constant dedication to elimination of safety hazards in their aviation skills. These are only a few of the questions in the human factors field. Many more will arise during these two days. Over the next few months, we will study the ideas and proposals that you've put forward here, and be able to build them in to a tentative program. At that time, we may find it wise to hold another such workshop to assess progress and to identify further areas for study.

Walt Luffsey, our Associate Administrator for Aviation Standards, will be in charge of that effort. He is here now to tell you what we are already

doing in the human factors area, and what sort of comprehensive programs we hope to establish for the long term. Thank you very much, and I now would like to introduce Walt Luffsey.

MR. LUFFSEY: Thank you Mr. Bond. Thank you Dr. Costantino.

Folks, it's a pleasure for me to be here, and I certainly appreciate the attendance, the interest displayed here. I think it's pretty obvious to all of us human factors is of high interest.

Air transportation is the safest form of public transportation in the world. FAA, and other government industry reports and other literature, indicate that human factors is perhaps the last unexplored frontier in aviation safety. Whether it's the last frontier remains to be seen. But what is clear at this time, is that the study of human error and ways to eliminate it, should provide valuable clues to methods of improving aviation safety. Aviation human factors, as a program, is the study of human elements in the entire system, and addresses all aspects of human behavior in the design, maintenance, and operation of manned machine systems.

Incidentally, throughout the conference, don't constrain your questions, discussions or interactions to only the disciplines or subjects represented by the panels on the agenda. In our view, we must seek broader coverage, including forums for commuters, controllers, general aviation, and so forth, and expect to do just that in the near future.

Our goal at this conference, is to establish a common perspective on human factors problems, and to identify the issues that, when resolved through our joint efforts, can lead to the greatest improvements in safety.

You were invited here to assist us in mapping an improved government program. We need to better understand the why of human error. The interfaces between people and our complex new technological systems, and to mitigate problems or hazards at such interfaces in both existing and proposed future systems. We must deal with elusive, sometimes abstract considerations and assess in an objective manner the pros and cons of the number of issues which aim at safety improvements.

The aviation community has long recognized that human performance in the activities of the men and women who cooperate and maintain aircrafts, the Air

Traffic Control System, and navigational aids are of paramount importance to aviation safety. This is evidenced time and again in accident investigations which reveal that large percentages of causal factors are attributable to human performance, or a little less positively, to human error, or the lack of adequate performance. We also recognize that a large number of reports in the aviation safety reporting system show the involvement of human error. Our conclusion that human performance enhancement deserves an elevated priority is supported by nearly every element of the aviation community. NASA, NTSB and DOD have highlighted the importance of gains in safety that may be attained through increased understanding and better applications of present knowledge in human factors. Concerned groups have called for more attention to the root causes of so-called human error. The simple logic is that blame provides neither the remedy nor prevention of repetition in the future. If we can find out why, we have a clue to the avoidance next time through by changing methods, practices or applications of complex systems and hardware. I believe that there is general concurrence that reliability improvements we have seen in engine air frame and avionics must be paralleled by comparable efforts relating to the human elements in aviation.

We have scheduled this two-day human factors workshop to bring together knowledgeable people from government, the industry, military, academia, and user groups to discuss these issues. To strengthen our human factors program, the Administrator directed me to establish a task force on human factors in the national aviation system. It has been given a broad base assignment to coordinate the FAA's human factors programs which study the implication of future developments in flight operations, air traffic control, aircraft certification, with respect to the potential for human error. And to assess the adequacy of FAA efforts to insure that new equipment and procedures are designed to be fully compatible with human limitations.

The next step is to identify requirements for human factor studies and information that are not already covered in the existing program in our current activities. The task force has to relay such requirements and has come up with some early needs. One of the major elements of need is concerned with the aviation equipment maintenance and grounds support performance. In the past, attention may have been so directed at the controller and the pilot that enhancement of the effectiveness of the technician and maintenance person has been relatively neglected.

Another of our perceived areas for study is that of pilot decision making, cockpit management and judgment. Psychological research suggests that judgment can be taught, and that appropriate use of performance information and feedback displays can motivate air crews to better adhere to standardized performance and procedures.

Again, this area of study appears to have been relatively neglected in the past, but may offer promise for advances in safety and efficiency in the future.

The third example is the need for handbook civil aviation human factors information. Aviation human factors covers a lot of territory. And not all the existing information is available to everyone. A current compilation of the state of the art in the aviation human factors field was cross referenced to particular topics and sources of design guidance information may be very useful.

What we really have to see happening in the next few years is the melding together of human factors knowledge. That already existing, and that produced by new programs. Aircraft design advancements, ATC systems and aeronautical aids improvements and technically advanced national aviation system that in turn achieves improved safety.

I, personally call on you here and the rest of the aviation community to help us with that task. Thank you.

MR. ANDERSEN: Okay, Cliff, wherever you are, could you bring your panel up here now? Thank you.

As you know, we have four panels convened here. Each panel will have three full hours for presentations and discussions.

It's my pleasure to introduce the first panel moderator, Mr. Cliff Hay, who is the Chief of Special Programs Division at the Office of Aviation Safety at the FAA. Cliff, it's all yours.

MR. HAY: It's both my pleasure this morning to be the moderator of the government panel, and to introduce the four speakers that we have.

First, it is my pleasure to introduce Mr. Neal Blake, the Deputy Associate Administrator for E&D. Neal has been with the Federal Aviation Administration now deeply immersed throughout his entire career in the agency

in the development and evolution of the national aerospace system. Neal is both an air line transport rated pilot and currently checked out as a captain in DC-9's.

We have next to Neal, Dr. Homer Reighard, who likes to be known as "Rick the rock". Who has been the Air Surgeon for the past year or more, and has been with the CAA and FAA for the period since 1953. Rick will speak on the behavioral matters and medical factors in aviation.

I also have the pleasure to introduce Colonel Robert Ettinger, the Chief of the Flight Control Division of the Wright Aeronautical Labs at Dayton, Ohio. A little bit about Bob here is, that he's been in the Air Force now for a little over 21 years, just came fresh from seven years in the F-16 flight test program, which we all envy him for. He has an MS in engineering from Ohio State, some 4,000 military hours and perhaps some 50 or more aircraft and I assume, from talking to him that those are all fighters. And has shared in 1979 the Kitchler Award, a very distinguished award.

Next to Bob is Robert Nysmith, who is the Deputy Associate Administrator for Aeronautics and Space Technology. Bob will be speaking for the management standpoint at NASA in the human factors area. Bob has spent 15 years at Ames in research and I'm sure many of you are familiar with him during that period of time, as well as the most recent six years in NASA headquarters. And has both a BS and an MS from the University of Kansas.

Without any further delay, I would like to take this opportunity, and indeed the pleasure to introduce Neal Blake, who will speak to you on human factors, the FAA Engineering and Development Program. Neal, if you would please.

MR. NEAL BLAKE: Thank you, Cliff, and good morning ladies and gentlemen. It's indeed a pleasure to be here to tell you a little bit about the highlights of our E&D Program in human factors.

The human factors area has been the subject of much study over many years, and the results of these studies have had a major impact on the aircraft and air traffic control systems in use today. So, in conducting our current efforts, we are not starting from "scratch," but rather, we're building on and improving the already high performance of the current system. The focus of our current efforts is not on so-called "knobology" or the location of displays

and controls best suited to the physiology of the human, although we recognize that this is an extremely important area, but rather rests on areas which include the following:

The causes and types of human error, and the impact of these errors on safety, performance and productivity of the aircraft operation and air traffic control system.

The definition of automation approaches that assume the continued existence of human, as well as machine error, and strive to avoid both the occurrence and the consequences of such error.

Assessment of the proper distribution of air traffic, and aircraft control, and monitoring functions between automation systems and the controller and pilot.

Determination of the appropriate interfaces between the man and the machine at each step up the ladder, leading to higher levels of automation, as well as the appropriate level of workload at each step.

Determination of adequate automated, semi-automated, and manual system back-up capabilities to permit safe continuation of system operations under a variety of conditions of human and machine system failure.

These areas of R&D are all directed toward the need to maintain and enhance the safety of the aviation system, to achieve improved performance of the system for the participants and the flying public, make the system more productive and constrain the cost of the system to the Nation. Of particular importance to this meeting is the achievement of improvements in the ATC system and in aircraft operation which take into full account the limits and capabilities of the men and women operating the system.

By way of background, in 1975 a special DOT task force study on the FAA safety mission recommended that "FAA undertake a major safety research program to assure that future systems are designed around reasonable criteria for human error." Concurrently, the Office of Systems Engineering Management undertook a study to identify human factors problems associated with both air carrier and general aviation accidents and incidents. This FAA study entitled "Program for Optimizing Crew Performance and Minimizing Human Error in Aircraft Cockpits" used as inputs safety statistics from a variety of sources and solicited the views of the aviation community for its perception of human

factors problems and potential solutions. After a great deal of internal and external discussion, several major problem areas were identified as primary candidates for expanded effort and formed the basis for establishing our current human factors program.

While research and development in human factors has been carried on for many years in association with specific projects, FAA determined in 1977 that a common thread existed between the programs and problems and that certain R&D umbrella management was needed to assure a fully cohesive program which responded to the identified problems and such a management structure was established. At that time although the programs were grouped into two broad areas related to pilot and controller problems, it was recognized that there are many similarities between the two areas and the problems occurring in them. Because even the term "human factors" is frequently misunderstood, we chose to talk about our programs in terms of the intended results; namely, Aircrew Performance Enhancement and Error Reduction (APEER) and Controller Performance Enhancement and Error Reduction (CPEER).

Today I would like to give you a brief overview of some of the efforts we have underway in these two areas. Many of these programs represent joint efforts with NASA and with the Department of Defense, which were undertaken to assure that the Nation's best resources are applied efficiently to these problems.

Starting first with the Aircraft Cockpit and Aircrew Human Factors Activities, our program in this area consists of several types of activity including problem analysis and program definition, aviation standards support programs, evaluation of the human factors aspects of new or upgraded cockpit systems and research is new techniques and concepts.

In the area of problem analysis and program definition, we have established a number of activities designed to quantify the problems and identify needed Engineering and Development activities. Some of these include:

Pilot Error Analysis. Historically, pilot error is cited as a factor in approximately 60 percent of air carrier and 88 percent of general aviation fatal accidents. Pilot error is also cited as a significant factor in aviation incidents. A continuing study is being made of the types and causes of human error to establish a basis for improvement of current systems and the design of new systems.

An analytical study of cockpit information requirements. The introduction of advanced cockpit design concepts and advanced air traffic control system improvements will present new requirements for cockpit information processing and display. It is essential that human and aircraft system capabilities work in harmony with the evolving air traffic control system. We plan to develop a series of recommendations for efficient means of displaying and using information in the cockpit for consolidation of information on electronic displays and for functional integration of aircraft functions. Proper integration of such new capabilities as collision avoidance advisories, wind shear information, Microwave Landing System flexible approach paths, Cockpit Displays of Traffic Information, flight management computers, and others, is essential. A similar review of information requirements is planned for the helicopter area.

Pilot Workload Measures. Although a great deal of work has been done on the subject of defining pilot workload measures, additional efforts are needed to develop fully acceptable, scientifically validated and widely accepted methods for measuring pilot workload. Some of the current efforts which we have underway to deal with this problem include the following:

1. Completion of a report entitled "Flight Crewmember Workload Evaluation" covering workload measurement techniques that have already contributed to successful certification programs.

2. A joint activity with the United States Air Force to survey and categorize all existing or planned workload assessment and measurement techniques.

3. An effort to develop and validate a set of subjective pilot workload measures that can be used to assess reliably the workload associated with current and advanced cockpits of aircraft operating in the current and future ATC systems. The intended end product will be a set of pilot rating scales for total workload measurement which is widely accepted and which can be used by Government and industry researchers as a common measurement standard. As an initial activity in this program, the subjective workload rating scale developed by MIT, which is based on an earlier method developed by Cooper and Harper of NASA, is currently being examined and validated at the Ames Research Center using airline subject pilots.

4. Another approach being followed recognizes the importance of full mission system simulation in characterizing workload scientifically. FAA and NASA are working together on the development of such simulations to be used as an aid in learning more about establishment of objective pilot workload measures to augment the large body of empirical and subjective information which now exists. Full mission system simulation techniques will also permit improved studies of the interface between the pilot and the air traffic control system where many human errors originate.

Runway/taxiway Transgression Analysis. A number of accidents and incidents have been caused by aircraft taxiing inappropriately onto active runways. Our objective is to determine the factors which cause pilots to make inadvertent or unauthorized takeoffs or incursions onto active runways or taxiways. An initial assessment of past transgressions has been completed and a report is in preparation.

Assessment of Pilot Performance in using Domestic and Oceanic Navigation Systems. Our present program is examining the relationship between separation standards and navigation system performance for en route operations. Human error and blunders in navigation are significant contributors to the failure of aircraft to navigate within designated routes. The program addresses the human factors problems related to the use of current VOR and area navigation systems which may contribute to the error and blunder problem. The program will be extended to evaluate new navigation systems including 4D time navigation, integrated flight management systems and problems unique to utilization of the Global Positioning System. An important objective is to examine advanced navigation system concepts to establish the data base needed to define guidelines and criteria that will recognize the special needs of single pilot IFR operations, and that will help to minimize pilot errors, blunders, and the workload.

We have underway a general aviation accident problem analysis. Eighty-eight percent of general aviation fatal accidents involve some element of pilot error. A detailed categorization of these accidents and the identification of the underlying human factors problems is needed. This is being accomplished through a review of general aviation accident and incident data bases to determine what the human factors problem areas are, and to prioritize them. The end product will be a rank ordering of problems and a definition of

the programs needed to resolve them. A significant part of this work will examine the relationships between weather-related accidents and current methods of instrument flight training. The program will also define and examine the effectiveness of alternative training programs.

We have conducted a study on the relationship of general aviation pilot judgment and training to aircraft accidents. Our objective is to develop a system of experiments to assess pilot judgment in selecting appropriate actions under varying cockpit, ATC and aircraft emergency conditions. We plan to examine the feasibility of preparing and providing training in the use of pilot judgment aids, such as cockpit reminders, checklists, and training aids, and to determine if pilot judgment training can offer specific benefits.

In addition to the programs mentioned above, which have application to helicopters, we also have underway or are planning a number of programs that relate specifically to the human factors problems associated with helicopters. In one of these programs is designed to define the minimum acceptable handling qualities for IFR flight in helicopters. Other efforts include analyses of accident data and a survey of helicopter operators to identify potential helicopter problems and characteristics which may contribute to helicopter accidents. These studies are expected to identify the major human factors problems affecting helicopter operations and aid in defining programs for their solutions.

The next category of programs are aviation standards support programs. This type of program is designed to review current regulations and procedures related to the human factors area with a view toward identifying potential changes related to desired system improvements. The following are representative of this type of task:

Examination of aircraft cockpit standardization. This program is examining the current status of cockpit standardization, and will seek to identify the potential problems that may result to lack of such standardization. We have conducted a survey of seven representative airlines to determine the present status of cockpit standardization between aircraft of the same type and between aircraft of different types, as an aid to identifying any problems associated with non-standardization. The product of this work entitled "Transport Aircraft Cockpit Standardization" will be information on the

current status of standardization and the benefits of additional standardization.

The second program has recently been completed on the effect on pilot performance of controller altitude callouts for ASR type approaches. This program addressed the value of providing mandatory altitude callouts by controllers during such approaches as it might relate to reducing landing accidents. The conclusion of this particular study indicated that altitude callouts did not significantly affect pilot performance in executing such approaches.

The third area relates to new and upgraded systems programs. The programs in this area represent developments initiated to respond to problems identified either in field operations or through the problem analysis programs covered earlier. The following are representative of this type of activity.

Our work on the windshear program, which is essentially complete, included a great deal of emphasis on the human factors aspects of the problem; namely, how best to determine and to present the information to the pilot. The airborne windshear program began with a series of manned flight simulation experiments to identify and then to refine the most effective pilot aiding concepts. In most subject pilot favored a system that displayed an airspeed-ground speed comparison. Another system that rated well in the evaluation utilized a "quickened" flight director logic. These results were validated in a number of simulations with airline and FAA pilots, and the results have been made available to the industry. In addition, a notice of proposed rulemaking on the subject has been developed and will be issued in the near future.

Development and evaluation of Head-Up Display presentations for civil aviation aircraft has been undertaken. The program seeks to define alternative display presentations and assess the potential benefits and also any liabilities of this type of information presentation on contributing to safer operations in air carrier aircraft during approach and landing phase. FAA has established a joint program with NASA to examine the potential of Head-Up Displays to aid the flight crew in reducing pilot workload, increasing reliability, and providing redundancy of information for navigation, flight path control, and other flight management tasks. The performance of flight

crews using the device will be assessed over a full range of operational and weather scenarios. Our purpose is to provide enough basic data to the industry and to our own aviation standards organizations to establish the capabilities, the limitation, and the minimum requirements for such systems.

Another program is defining and evaluating approaches to improving aircraft alerting and warning systems in use in the current generation of air transport aircraft. Current systems are being examined to determine those factors which could contribute to pilot judgment error and to incorrect remedial actions. Further, current systems may not indicate the priority order in which critical actions should be taken when multiple or catastrophic failures occur.

This program has been underway for several years, with participation from the three major U.S. civil transport aircraft manufacturers. Our objective is to develop guidance for the functional standardization of air transport cockpit alerting systems, particularly with regard to the use of automation and new displays of alerting and warning data. We have encouraged the airframe manufacturers to work together to coordinate the development of a standardized industry alerting system concept. A major study entitled "Aircraft Alerting Systems Criteria Study" has been completed which lays out the dimensions of the problem, and recently, two improved alerting systems concepts were designed and are now being tested in simulation. We are planning to go beyond this effort to concentrate on much more advanced methods of warning, which take into account the changing priorities of warnings with flight phase and the need to account for problems which may be associated with highly unique occurrences, such as a physical separation of an engine from the aircraft. We have been working on research into more intelligent warning systems which can provide not only prioritized alerts and warnings, but which may also be able to provide diagnostic capabilities that will offer the pilot the best alternative course of action instantly, based on computer-aided analysis of the aircraft state or problem.

The fourth area are called Research Investigations. This type of program is examining the potential of new techniques or concepts for improving system operation. Some of the current activities include:

Extension of the use of computer-aided analysis techniques to provide computer-aided decision-making capabilities for the cockpit systems. Current air carrier aircraft have complex emergency and failure procedures and checklists and in cases of multiple system failures, the likelihood of intermingling checklist procedures is high and the consequences potentially severe. In this program we have investigated the feasibility of applying computer-aided-decision-making to analyze complex and interacting aircraft systems so that unusual failure situations can be detected and remedial actions recommended to the pilot. We believe this work may show that computers, which have a knowledge data base and programmed reasoning ability, can assist the pilot in high workload situations.

The next program is examining the use and benefits of Cockpit Displays of Traffic Information. While the technology to provide traffic information in the cockpit certainly exists, the pilot's ability to use this information and the impact this will have on the air traffic control system is not fully known. Our objective is to evaluate the use of such displays for both passive and monitoring, and active spacing tasks so that the advantages and disadvantages of such use can be measured in terms of system safety, capacity, and efficiency in operationally realistic environments. We want to evaluate the impact of the CDTI on the pilot and on the controller, as well as the impact of CDTI on traffic flow stability, dynamic merging and spacing, display content and format, and pilot/controller workload changes. This work is being done jointly by FAA and NASA and is addressing general aviation use of such a system as well as air carrier use. Closely related to this work is other programs that relate to the examination of various types of display for the presentation of information of traffic advisory or collision resolution, which were associated with the beacon collision system avoidance systems and the automatic traffic advisory and resolution service system.

I'd like to shift gears now, and talk about controller related human factors activities. Our program in this area consists of tasks dealing with problems analysis and program definition, evaluation of the human factors aspects of new or improved ATC systems elements and research in new techniques and concepts.

This activity area contains the programs needed to quantify problems and identify needed programs.

Controller performance and error analysis is the first in this group. Just as in the case of the aircrew, errors occur in the air traffic control system. Although the rate of growth of system errors has been greatly reduced through implementation of ground automation capabilities such as radar data processing and conflict alert, the total number of such errors has been rising slowly, with a 1979 total of 612. A system error is defined as an operational error, involving aircraft being provided air traffic control services, which results in less than applicable separation being maintained between two or more aircraft. The system error figures are small -- less than two a day in a system which handles more than 30 million aircraft annually in centers and nearly 70 million in towers. Many system errors represent very small violations of the separation minimal however, the occurrence of any error is considered important. An analysis of these errors showed that over ninety percent of the errors involved human frailties such as inattention to duty, poor judgment, lack of coordination among controllers, failure to properly identify aircraft and poor communications skill. These findings have resulted in the establishment of controller performance improvement projects aimed at the elimination of the causes of error. The introduction of advanced data processing and display technology into the ATC system has brought the potential of new sources of system error in terms of controller interaction with such automation. Such issues as controller boredom, inappropriate intervention into automatic control and the inability to detect and intervene in automation failure situations have led to the establishment of projects aimed at defining appropriate controller roles, compatible with increasing automation.

One of the programs initiated to deal with the problem of system errors causes is the development of standard operating practices using groups of field controllers to establish best techniques for generating and implementing control actions. Also, we have under development a listening and remembering course for controllers to help improve controller communications skills and, thereby, to reduce the incidence of system errors.

With respect to the evolving air traffic control system, a number of specific human factors problems are being addressed. These include:

1. The optimal level of automation and the ATC process.
2. The role of the controller in an automated environment.

3. The ability of the controller to perform his assigned job in that environment.

4. The optimal design of the interface between the controller and the computer.

5. The optimal level of workload for the controller.

6. The feasibility of the concept of proceeding to very high levels of automation termed "auto-controller" which is somewhat analogous to operation of the aircraft on "auto-pilot."

7. The impact of passive and active self-separation functions of CDTI on the controller.

Obviously, the impact of increased automation on system safety and efficiency must be demonstrated prior to implementation. Our objective, therefore, is to characterize and measure the impact of different roles for man and machine in a more automated system. We are in the process of defining conceptual approaches to the higher levels of automation and will make assessments of system performance at several levels of automation and the associated man/machine configurations.

Development of a systems effectiveness measurement program. In the area of air traffic control simulation technology and methodology there is no currently accepted set of measures of system performance that can be objectively utilized to assess accurately the impact of changes to the existing system. We have underway the development of a system effectiveness measurement system for evaluating controller and system performance to provide more objective measures of the impact of change to the system. We expect to develop an ATC experiment designer's handbook which will provide objective measures to be used in assessing the impact of changes to the system.

Changing now to program for new and upgraded system activities. The activities in this area relate primarily to the continued improvement of the man-machine interface and the evolution of that interface as the level of automation increases and includes:

Electronic Tabular Displays of Flight Data for the Controller. Human factors considerations form an important part of the development of new electronic data displays, such as ETABS and the terminal equivalent which is

called TIDS, Terminal Information Data Systems. These considerations span the range of degree of automation of the flow planning process to the optimization of data entry techniques and hardware.

As a part of our program for the future automation system, we have under development a set of controller suite mock-ups which will show several stages in the evolution from the current to the future automated functions and associated procedures. We have established an intra-service FAA working group to establish future design requirements for the controller suite representing the future most advanced ATC system. Its aim is to provide design guidelines, functional descriptions and requirements for the new display system.

As new functions are designed and made a part of the ATC system software, the methods for displaying data to the controller must be carefully evaluated. Examples of new software functions which will require an optimally designed man/machine interface are en route metering, terminal metering and spacing, conflict resolution, and a variety of data link applications, and the advanced en route automation functions.

Closely associated with the preceding program is an activity to analyze the radar controller information sources, his data needs, his utilization of currently available data, and to develop requirements for future system display formats and information content.

Research programs represent investigations into new techniques and concepts. These include:

Investigation of the controller end of the CDTI-ATC interaction loop. This program will investigate the changes in controller actions implied by various redistributions of the control functions between the controller and pilot, controller impact and workload implications of various CDTI passive and active functions and special interface hardware and software design requirements needed to achieve compatibility between the two systems.

Another area of investigation is the use and human factor benefits of the use of color in plan view situation and electronic tabular displays.

In summary, there is much more we need to know, particularly about the fundamental human capabilities and limitations. Further, we need your help in defining scientifically objective measures of workload and measures of

system performance. We solicit your thinking as to how best to get at some of those fundamentals in a way in which practical results can be achieved -- results which we can apply with reasonable hope that gains can be made in reducing aircrew and controller errors. This brief program overview is intended to provide the workshop with an indication of the types of activities which are underway or planned in our current APEER and CPEER programs. We recognize that these programs represent only a start toward the efforts needed to address the human factors problems in present and future systems. So, we are looking forward to receiving the inputs from this workshop to help us to expand and also to focus our human factors program. Thank you.

MR. HAY: Thank you, Neal. At this time, Ild like to introduce Dr. Homer Reighard, who will speak on the behavioral and bio-medical factors in aviation. Dr. Reighard.

DR. REIGHARD: Thank you, Cliff.

This will be such a brief summary of some of the activities in the area of bio-medical and behavior sciences that should be viewed as complementing and supplementing the overall efforts as outlined by Neal Blake.

I'd like to talk briefly about our potential for doing studies or research in these areas mentioned resources, and organization but just briefly the total effort in the area of bio-medical and behavior sciences research is possibly a $2 million program, annually.

The research that we do is almost exclusively in-house. We have a research branch as a part of the Civil Aeronautical Institute in Oklahoma City. There are some 65 to 67 people involved, some 20 of these as professional level scientists.

We are organized back in that branch into four laboratories, and this will give you some idea of the areas of effort. The psychology laboratory and the physiology laboratory, the toxicology and pathology laboratory and the protection and survival laboratory.

In the Washington Office of Aviation Medicine, we have a Bio-medical and Behavioral Sciences Division, one of five divisions in Washington whose primary mission is to interface with all other elements of FAA, in an effort to identify requirements for bio-medical and behavioral sciences research in support of other agency programs.

We have positions for five program scientists within this division, and I'll mention those areas: Human performance, human resources, accident investigation, medical standards and protection and survival.

When needs for bio-medical behavior sciences effort is identified, these needs are put in a program guidance document which is issued two years in advance to the aeronautical center where the civil aero medical institute resides.

We are also prepared, and perhaps this is an area where we do most of our contributing work. We're prepared to respond to ad hoc requests either from within FAA or from the industry.

I'd like to talk briefly about some recent or ongoing activities, just as an example of the kinds of things that we have worked on or are prepared to work on.

Since we're here in Boston, I couldn't miss the opportunity to mention that one of our more comprehensive studies funded in the recent past, and this was a contract study was a study by the Boston University. That was a five-year study entitled health change in air traffic control. And it was an effort to come to grips with some obvious questions concerning workload, concerning stress, and the effect of the work of air traffic control on the health of controllers.

Also in a controller area, and this work has been done by mostly behavioral scientists on our staff in Washington. For the past several years, we have worked on the revision of the selection test battery for air traffic controllers, The end product that's now at hand will be, we believe, a significantly improved way of identifying those controllers who -- those persons who, as controllers will have the skills to operate effectively and efficiently in that occupation. As I say, we have the test battery at hand. It's a matter now of the Office of Personnel Management, formerly Civil Service Commission to officially improve and implement it into its examination series.

We have evaluated air traffic control training. The economy at which the controllers are trained is physically located at the Aeronautical Center in Oklahoma City, and behavioral scientists have for a number of years and will continue to be involved in evaluating the results of training. Beyond the

training of air traffic controllers, we have an interest in and have done studies with regard to factors relating to attrition of air traffic controllers. We've studied the effects of shift rotation, and we have studied, and will continue to study the levels of alertness and efficiency that are associated with varying workloads, I'm talking about controller now, and the increasing automation of the system. Again, complementary to other efforts within the engineering and development complex.

In the area of environmental and survival factors relating to the aviation system, I will mention a few examples of activities we have prepared an oxygen equipment human factors design guide. We have estimated the biological effects of ozone both, as far as crew members are concerned and also on passengers.

We have done numerous studies in the general area of crashworthiness and survivability, and we have selected particular aircraft and systems, particular aircraft and systems, particularly restraint systems for specific investigation.

We have done studies relating to the effect of handicapped passengers on the evaluation effort following crashes, and we've specifically studied the situation involving blind persons aboard aircraft who wish to carry their canes with them.

We've done extensive studies, and continue to study the matter of the biological effect of the toxic materials which comes from the burning interior cabin materials. Hopefully, this will contribute to the eventual establishment of a combined hazard index relating to fires following aircraft crashes.

We've done considerable work as a consequence of accident investigation of air carrier accidents in establishing patterns of injury and evacuation scenarios.

As far as air crew performance were concerned, or before I leave the environmental and survival studies, I should mention the fact that the basic data, the data base for the development of a computer model for evacuation evaluation was developed at our research branch.

Air crew performance studies -- we have an interest of course in those situations that might be expected to degrade performance, and here I think of the effect of various drugs on pilot performance. We have to be sensitive to

the fact that some therapeutic drugs might be compatible with continued safe operation despite the facts that these drugs are being taken. One, in the area of hypertension treatment, it is very popular and there are many pilots who have this disease, and we have a concern as to whether it degrades performance, and specific studies are done in that area. That drug is Propranolol.

We, of course, over the years have done many studies relating to alcohol. The reason we've put such an emphasis on this drug is that some ten percent of employed populations are known to be alcoholics, we have no reason to believe this is any different for pilots. As a matter of fact, we have some evidence, direct evidence as well, that airline pilots are concerned. Also anywhere from 10 to 12 percent of fatal general aviation accidents have significant levels of blood alcohol demonstrated in the pilot. Significant, for our purposes is 50 milligrams percent or more. So we have not only studied the rate of which the bodies of pilots killed in aircraft accidents are found to possess alcohol, we are studying such things as hangover and the effect of degradation of performance with small amounts of alcohol. The end result of this, we hope and has already been to some extent an educational effort to attempt to call to the attention of the flying individuals the importance of avoiding that drug.

We have evaluated performance of pilots with regard to various approach slope indicators, and attempted to understand some of the visual cues that are used by pilots in judging their relationship to runways, particularly runways with varying width, and in varying terrain background features are present.

And I mentioned accident investigation studies, we, as resources permit, attempt to study as many of the fatal general aviation accidents as possible, and participate in the investigation of all fatal air carrier accidents, and the basic studies here are autopsies, toxicological studies, crash injury investigations and so on.

I've attempted by example to give a general overview of the activities relating to bio-medical and behavioral sciences research in the FAA, and I think you will see it is complementary to those efforts which Neal Blake reviewed in the overall.

Thank you very much.

MR. HAY: Thank you.

Now I'd like to take the pleasure to introduce Colonel Bob Ettinger, from the Flight Dynamics Lab at Wright-Patterson Airforce Base. Bob will discuss the Department of Defense activity in this area.

COLONEL ETTINHER: Thank you.

Dr. Reighard mentioned the environment and its effect on human factors. And it's obvious it's fairly cold in here, and that's good, it makes my hangover feel better and keeps you awake, but it's very hard on the recorder, whose hands are so cold, she can't type.

As most of you can imagine, after 20 years in flying fighters, I'm experiencing severe human factors and the workload problems trying to get my desk to maneuver.

It is a great pleasure to address this group. All across the Department of Defense, we are greatly interested in the human factors aspects of military aviation.

This paper represents a series of personnel opinions mixed with the current advanced research programs being conducted by the Flight Dynamics Laboratory. The Flight Dynamics Laboratory is part of the Air Force Wright Aeronautical Laboratories or AFWAL at Wright Patterson Air Force Base near Dayton, Ohio. AFWAL is part of the Air Force Systems Command under the Director of Laboratories, this paper does not represent the opinions of the Department of Defense or the USAF.

I will attempt to briefy contrast the military and civil flight profiles, take a look at some of the advanced technology programs which we're working on, relate our experience with a modern methodology for crew station design and talk briefly about the human operator, and introduce you to the Tri-Service Human Factors Technology Advisory Group.

We view the modern military pilot being at the center of a complex information system. He is part of a systems engineering problem which includes the aircraft motion sensors, the aircraft weapon system and a large amount of external information, some of it coming from intelligence sources, from threat warning systems, from Airborne Warning and Control Aircraft or AWACS, from Global Positioning Satellites. This information comes to on-

board computers perhaps with inertial navigation subsystems will process this information providing situation information and steering information to the pilot. The pilot relays his decisions to the computational power of the aircraft and the aircraft responds and the process starts all over again.

The military pilot is required to operate in all segments of the civil or commercial flight profiles, plus things like air-to-air combat. Air-to-air combat may be pulling up to 9 G's in the slope-back seat of an F16. Air-to-surface weapons delivery including low level penetrations, target acquisitions, target attack, egress aerial refueling. The threats facing the military pilot include: The weather, traffic and terrain facing the civil pilot, plus surface to air missiles, anti-aircraft artillery and opposing fighters. The fighter pilot is usually in a small, single place cockpit. He is young with a limited amount of flying experience. His aircraft tends to be more maneuverable and respond quicker. The complex target area, such as shown in this slide, he has to deal with weather, defenses, smoke, decoys, and camouflage. All of these serve to increase the time restraints which he faces in the target area. With this already extreme workload, the introduction of new subsystems may serve to increase the pilot workload rather than decrease it. It should be obvious why the U.S. Air Force is interested in the applications of new technologies to decrease pilot workload.

One of the Flight Dynamics Laboratory's technology thrust is the integrating flight management for the military missions. We are currently conducting studies and analyses to determine optimum display and information requirements for the total military mission.

This slide depicts a fighter cockpit with five cathode ray, multi-mode display tubes and a wide screen heads-up display. One very promising system we are exploring today is an integrated missions planning and data transfer system. It's very frustrating for a fighter pilot to go and jump in your jet, start it up and spend 20 minutes typing in the elevation and coordinates of the waypoints or targets. A digital transfer unit about the size of a cigarette case which allows you to plan the mission in the briefing room, enter and verify the coordinates and evaluate at your leisure and transfer that pre-planned mission information to the aircraft in a matter of seconds is very promising.

The multi-function displays in this cockpit reduce eye scan and conserve cockpit real estate. They enable controls to be multi-functional, reducing the need for dedicated controls and allowing controllers to be placed in areas of easy excess. Advanced versions of the F-16 with night, or weather, attach subsystems would require something like 1300 separate switches and buttons if each were dedicated to a single action. The proposed use of multi-function displays greatly reduces this count.

In this view of the same cockpit, the electronic attitude indicator display has been replaced by the Joint Tactical Information Display System or JTIDS format. In this case, the pilot is relying on the attitude information displayed on the head-up display you can't see in this particular slide.

Here's a close-up view of the JTIDS display. It's very similar to what the FAA calls the Control Display for Traffic Information or CDTI, you heard about earlier. In this complex array of some 30 threats guns, surface-to-air missiles or aircraft, the use of color automatically prioritizes your attentions to the important threats. In a traffic information display system, the red symbols would be for those aircraft on the collision course within say 2,000 feet of your altitude. We have looked at some displays where color serves no benefit. We, in the Flight Dynamics Laboratory are working to establish a standard for color symbology.

As the pilot's workload increases, it may be necessary to off-load the pilot with automatic flight control systems. In this view, the lower display has a north-up horizontal situations display for an integrated flight trajectory control systems. Based on a pre-selected minimum or maximum air speeds, say 350 or 500 knots, the computer gives the pilot a latest or earliest time which he will arrive at a pre-decided target. The pilot then selects the desired time on target. The automatic flight control system and automatic throttle gets the aircraft to the target on the time. If a new threat appears or a new target is assigned, a redirect process begins with a new time and target range. Such a redirect is shown in the dotted line in the lower right on the display.

As the requirement for the military pilot to fly at low altitude at night and in all types of weather increases, we are experimenting with synthetic perspective terrain displays such as shown here. This display could

use a combination of stored digital land mass data, low signature radar and a high resolution inertial navigation system for inputs. Could you fly at 200 feet above the ground at 400 knots using a display like this?

As airborne color computer generated displays come into being what about a display like this? With the digital land mass data, if we know there's a bridge in such and such a location, why can't we display one. Perhaps the artist over did it with this view of a computer generated shadow under this bridge. It must be based on some stored position information day, date, sun and moon angle so that you could get that in the right place.

Maybe we could combine threat, trajectory and terrain information in a computer generated prospective display such as this. A synthesized data like this could, maybe on a head-up display, could be used to simplify and clarify situations information to the pilot thereby reducing his workload.

The Navy, the Air Force and the FAA are interested in the applications of voice command systems. When both hands, both feet and your sphincter muscles are busy in combat. Maybe a voice command system may be useful to lock on a missile. Voice command could be used as a means of two-way conversation. Can you imagine your jet saying, "Roger, sir, you are locked in, shoot, shoot." Recorded voice warnings are used in some systems right now. That's what a night refueling feels like.

To leave what my friends in the Tactical Air Command might call the engineering wet dreams of the future, I'd like to spend a little time talking about the methodology for crew stations designs developed by the Flight Dynamics Laboratory. The Tanker Avionics Aircrew Complement Evaluation or TAACE Program was conducted by the lab to determine the feasibility of operating the KC-135 with a flight crew of three, pilot, co-pilot, and boom operator, eliminating the current requirement for a navigator. The structured, organized crew station design methodology can be divided into the five separate steps shown over at the left. The first step is a mission analysis phase. In the TAACE Program, we went to the Strategic Air Command, the users of the KC-135, and let them help us define the relevent mission. Flight Dynamics Lab personnel flew on 21 SAC missions observing the air crews in actual operation. The SAC crews also participated by completing a questionnaire to help evaluate their workload.

An average workload rating was generated by the air crews for each mission segment. It's not particularly surprising to this audience, I guess, that the departure, descent, and landing phases of flight had the highest relative workload. That's all that photograph shows. It's very hard for you to see it.

Based on the mission analysis and the operational scenario, three candidate crew stations were developed. The first, a minimum update was the baseline tanker cockpit with the addition of a dual inertial navigations of other displays. A moderate update included vertical engine instruments, navigations management integrations, and integrated caution and warning panel and four electronic displays. The major update consisted of an expanded navigation management scheme, automatic fuel management panel and nine electronic displays.

During the mock-up evaluation with 9 SAC air crews, the three candidate concepts were evaluated against the operational scenarios. A composite crew stations evolved which included the expanded navigation management panel, a redesigned fuel management panel and four electronic displays. This crew station also had vertical engine instruments and an integrated caution and warning panel.

The composite crew station shown here was used for the simulation and validation step. Fifteen SAC crews flew approximately 40 hours each in simulated flights using this simulator shown on the right. We believe this cockpit makes more use of integrated displays than any other except that proposed for the Boeing 757 and 767. The results of this evaluation are summarized on this slide. The SAC tanker mission could be performed with a 2 pilot, one boom operator crew with a suitably updated crew stations. A hot bench mock-up and simulation with flight hardware is currently underway to transition the cockpit design to engineering development. A light phase program is planned as a final verification of this concept.

The human operator may be looked at as an inaccessible black box, which can only be studied by introducing known inputs and analyzing the resultant outputs. It would be nice if we could create such a black box to predict operator performance in complex work stations in different mission segments. The U.S. Navy has a Human Operator Simulation or HOS system and the U.S. Air

Force Aerospace Medical Research Laboratory has a scheme called Simulation Analysis of Integrated Network of Tasks or SAINT. And the Dynamics Flight Laboratory is busily developing a pilot model where the time response of the model follows a stochastic distribution to account for the variation of the human operator. Pilot models like these are subject to constant tuning through refinement and validation as the human factors data expands. We are seeking to use these pilot models as a preliminary design tool or a first order cut at new crew stations designs.

My last subject is the Tri-Service Advisory Group on Human Factors Engineering. This is a DOD sponsored group with NASA as an invited participant. So far four sub technology advisory groups have been formed for workload, test and evaluation, voice interaction and human factors standardization. A fifth sub group to cover the human factors engineering in the logistics area has been proposed.

In conclusion, I have tried to point out several areas where technology might provide potential solutions to the increasing workload of the military aviator. I have outlined a crew station design methodology which we feel has merit. We also talked a little bit about developing preliminary work station design tools using pilot models.

Thank you, very much.

MR. HAY: Robert, your reputation is always served for an always interesting and thought provoking presentation. For that, we thank you.

Now, it gives me great pleasure to present Bob Nysmith from the National Aeronautics and Space Administration to discuss the management aspects in view of human factors at NASA.

MR. NYSMITH: Thank you, Cliff. I'm glad I'm on now, I think Bob woke everybody up. I thought that was a very stimulating talk, although it's difficult to see from up here. Let me give you a clue, I think you guys have a better view than we did.

I would like to thank the FAA really, for this opportunity to be here and to be able to discuss the NASA perspectives on aviation human factors; and to say some words about how human factors fits into our priorities, what we have to offer, how this capability that we have came into being, and where we plan to go from here.

To get into this, I'd like to briefly cover a bit of history, because it is relevant to what NASA is doing today, and what we are planning for the future.

Many, if not all of you know, and it depends on your age more than anything else, that NASA is the son of the National Advisory Committee for Aeronautics, which was established in 1915, really because it was recognized at that time that aviation was going to be an important force in the future and that the government had to have a rule and needed to initiate the research in aeronautics.

An interesting fact that's totally irrelevant at this workshop and anything else is that the NACA budget in those days in 1915, was $5,000. Another interesting fact is that we couldn't spend it all, and we had to turn some of it back. And I'm happy to say that NASA has never had that problem.

In 1958, when NASA was created from NACA it was chartered among other things in space, but it was chartered in aeronautics to conduct research too as to contribute materially to the improvement of the usefulness, performance, speed, safety and efficiency of aeronautical and space vehicles.

Acting under this mandate, NASA has functioned since its inception as an independent agency whose basic product is new knowledge and technology in the aerospace field.

Since the end of World War II, NASA and its predecessor, NACA, have recognized the critical importance of man/machine interaction in the increasingly complex, high technology aviation system. As far back as the 1940's, NACA investigated the topic of aircraft handling qualities. This required the development of systematic methods for assessing the man/vehicle interface. One of these, the Cooper-Harper rating scale, remains a primary tool for making such assessments today.

The work of early NACA researchers in the area of handling qualities prompted our development of large scale simulators in the 1950's. It was recognized that the new jet aircraft would have to be able to operate in a wide variety of environments in order to be able to achieve their full commercial and military potential. Simulators were of pivotal importance in the assessment of clear-air turbulence effects and of man's ability to function in

low level, high speed flight. Work on aircraft handling techniques in wind shears and wake turbulence has continued to this time.

There are clearly problems for which solutions cannot be found quickly because not enough is known about basic human attributes. While NASA's primary concern in the human factors area has always been with the applications of scientific knowledge, we recognize the need for fundamental studies. Our work in aircraft control, for example has continually been supported by a variety of fundamental studies of man as a controller. Research into pilot modelling has been underway both at Langley and Ames Research Centers since the 1950's.

Last but not least, has been NASA's continued dedication to the development of improved cockpit displays. Many of you are familiar with the tunnel in the sky and pathway in the sky displays developed at Langley in the Terminal Configured Vehicle Program. It was very heartening to receive a letter from Boeing stating that TCV research in display symbology has contributed significantly to design decisions for the forthcoming 757 and 767 aircraft.

NASA's present aviation human factors program is based on historical foundations such as those I have just mentioned. Of course, our present program is significantly influenced by two important factors. The first of these is information as to the present problems as gathered from the FAA, the NTSB and the aviation community; and the second the perception of NASA researchers as to the problems most likely to be encountered as new technology for the aviation system evolves.

Our present human factors program has three main thrusts: flight management, flight safety, and simulation technology. I will briefly summarize some highlights in each of these areas.

The first is flight management. During the last decade, the emphasis of NASA's human factors program has gradually shifted from a primary focus on aircraft control to an emphasis on the perceptual and cognitive skills necessary for effective decision making. The Terminal Configured Vehicle, for example, is designed to evaluate the management of an aircraft in the terminal area, not the closed-loop control of that aircraft. Current research using the TCV includes an evaluation of altitude centered versus flight path centered EADI's and research on displays for minimum fuel profile descents and

for high speed turnoffs. Flight management research in the general aviation area is being performed under the Single Pilot IFR Program, which investigates the problems of single pilots operating under instrument flight rules. The TCV and SPIFR Programs are both at Langley Research Center.

Both Langley and Ames are participating in the joint NASA/FAA research program on Cockpit Display of Traffic Information.

Ames' research projects in flight management include: crew resource management, the role of automation, head-up displays and circadian desynchronosis. Ames is also carrying out a program focused on the specific human factors problems of helicopters flight which includes studies on the use of voice for making control inputs, and the use of auditory displays for wire obstacle avoidance.

Our primary emphasis on human factors in flight management is supported by the Aviation Safety Reporting System which gives clear evidence that the primary deficiencies in the present aviation system relate to the management of information within and among the various system components.

Speaking of the ASRS, I will move on to the second major thrust of our human factors program, aviation safety. An understanding of how the human operator behaves in the aviation system is often not sufficient to point the way to more desirable behavior. It is necessary to know in considerable detail why anomalous behavior occurs. The NASA Aviation Safety Reporting System, undertaken five years ago at the request of the community and the FAA, collects data regarding operational problems and human errors in the aviation system. Its 25,000 reports have been carefully analyzed to determine factors associated with such errors. Hypotheses generated by these data are a motivating factor for much of NASA's human factors research; the data serve to illuminate the problems of which work is most urgently needed. The system has provided data and analytic studies for over 30 other agencies and organizations in and outside the government; its methods are under study for possible adoption by other nations.

The third and final thrust of NASA's human factors program is simulation technology. This thrust covers research in all aspects of simulation including hardware and software improvements, computer configuration, improved visual cue generation, optimal controller methods of the pilot/simulator

system, and last but not least, training methodologies for making maximum use of available simulator technology. This last area includes a study conducted jointly with United Airlines on the feasibility of full simulation training which has just been completed and is leading to an additional study of simulation performance measures.

I have overviewed NASA's present human factors research program and provided a brief historical perspective of some of the trends from which this program evolved. In this process of evolution, NASA has continuously and deliberately set about building a preeminent capability for aviation human factors research. Four aspects of this capability deserve mention.

The first is the close ties that NASA's researchers have developed with all elements of the aviation community, both through the formal mechanism of its advisory committee structure and informally through close contact with DOD, FAA, air carriers, aviation manufacturers, representative and user groups and labor organizations. NASA's responsiveness to the stated needs of the community and the objectivity of its results have created, over several years, what I believe to be an atmosphere of credibility and trust in the human factors work of NASA.

The second capability is keyed to our facilities. NASA's aircraft simulators, including the Flight Simulator for Advanced Aircraft and the Vertical Motion Simulator at Ames, and the Differential Maneuvering Simulator and the Terminal Configured Vehicle Simulator at Langley, constitute a powerful set of human factors research tools. The ability to tie these into the FAA Technical Center's Air Traffic Control Simulator is an added plus. Our efforts in the development of a preeminent simulation capability continues. In the Fiscal Year 1981, we are starting the construction of the Man/Vehicle Systems Research Facility at Ames, which is a seven and a half million dollar investment. This facility consists of one conventional and one advanced cab together with an air traffic control capability. This slide shows a representation of this facility. When constructed -- that's my only chart, by the way, you guys. I don't want you to hurt yourselves moving across the stage.

When constructed, this facility will constitute the most flexible full system simulation facility ever built for aviation human factors, and it will be dedicated solely to human factors investigations.

The third aspect of our overall human factors capability is personnel. Within Ames and Langley we have a cadre of experienced human factors investigators and supporting staff, a number of whom have achieved international reputations. They represent, in sum, the only substantial human factors group devoted to civil aviation human factors in the western world.

The fourth aspect is NASA's independence. It is important to recognize that a major reason for our program's present strength is that it has not been confined to the study of short term issues. Many of our present program elements were proposed and implemented by investigators whose notions were not in accord with the conventional wisdom of the time. Our independence and reputation as an objective third party are central to the success of our programs. The Aviation Safety Reporting System is an excellent example.

We believe that these four factors; an effective working relationship with both the FAA and the aviation community, unparalleled resources, an excellent professional staff, and a reputation for independence and objectivity, constitute a major force in being for NASA's human factors research program.

A review of NASA's human factors research programs, past and present, indicates that NASA has achieved an understanding of the basic human factors problems confronting the national aviation system. This understanding, arrived at over several decades, has motivated the development of the research capability that I have just described. At present, this capability is both substantial and credible. Moreover NASA is committed to a considerable expansion of our effort in human factors. We have increased our resources, funding and manpower in Fiscal Year 1981 over that of 1980 and we intend to expand that effort ever more in Fiscal Year '82.

The content areas of these program expansions will be those described in our testimoney to the Cannon Committee hearings last August; namely, flight deck resource management, information transfer and the role of automation.

We believe that the expanded program to which I have referred will have substantial benefit with respect to aviation safety and system productivity.

Thank You.

MR. HAY: Thanks very much, Bob.

Just before a short break here, I would like to ask you to set aside 15

minutes for this, if you'll return promptly at that time, we'll enter into our discussion phase.

One final thing, should any of you have a statement to make from the floor or a presentation that you would care to make or view graphs or other materials to be utilized, I must advise you that this -- a record of this conference is all going into the dockets of notices of proposed rule making that are now in existence and open. Therefore, the material will become part of the record and we will have to ask you for copies of it, anything that you speak to. Thank you.

(Brief recess taken.)

MR. HAY: I thank you for your attention this morning, I would like to say again, and this applies to all of the panels for the next two days, that questions and answers that are given, material that is described or presented from the floor, we will need to have made available to us for the official record. If there is information of a proprietary nature, we suggest you understand that.

Now, I'd like to start off this portion of the session with any questions or any statements that anybody may have from the floor. I would simply ask one thing: Please state your name, the organization that you are with. Are there any questions?

We can't be getting off that easy.

DR CHARLES GRAHAM: I'll try the first one.

MR. HAY: Thank you.

DR. CHARLES GRAHAM: I'm Dr. Charles Graham from the Midwest Research Institute in Kansas City.

I'm curious in the programs that were described this morning, is there any attempt to use psycho-physiological measures to examine workload, losses of attention, attraction of attention, those kinds of measures?

MR. HAY: Dr. Reighard?

DR. REIGHARD: There have been psycho-physiological studies performed mostly with regard to air traffic controller performance. We have a simulation system at the research branch at the Civil Aeronautical Institute in

Oklahoma City, a so-called audible performance test battery, which can be programmed to provide a variety of stimuli and a variety of kinds of presentation and time sequence in ways that can modify workloads. So we do have a fair capability of studying the controller workload tasks.

We have done some work in the aircraft simulators at the Aeronautical Center as well. But our greatest focus to date has been in the air traffic controller area, psycho-physiological tests, and of course we have done numerous tests on the by products of stress hormone generation in a variety of settings including the actual air traffic controller workload environment and to some extent involving FAA pilots involved in flight inspection missions where they make multiple approaches to landing in a given work hour -- in a given work day, I should say.

So we do have some of this data, some has been published and some will be published in the future.

MR. HAY: Are there other questions?

MR. C.O. MILLER: I'm C.O. Miller, and I'm with Systems Safety Incorporated.

I would like to preface my question with a premise. If you accept the premise, then the question has some meaning, if you don't, I'll sit down.

I go back to what Walt Luffsey said about the marked improvement in hardware performance over the years. I submit to you that one of the reasons for that marked improvement of hardware over the years has been what I would call structured professional, and in most cases, team investigations to the hardware problems. This is the feedback loop to what we're all trying to do ahead of time. If we don't on occasion, and we have accidents and incidents, therefore you investigate to find out what really happened.

My question is, which agency, if anyone has expended any appreciable resources or time to develop a protocol for human factors investigations? If they've done it, I'd like to hear about it. If they haven't, I'd like to know why they haven't. And I think I have some feeling for what's in existence in this field.

MR. HAY: Thank you, I'll ask first Neal Blake to respond in his views from the FAA standpoint, and then Bob Nysmith from NASA. Neal?

MR. BLAKE: Well, I think we've spend a good deal of time digging into some of the basic factors underlying what causes human error. Now, an example of that would be the investigation of controller systems errors. It starts off with a detailed examination of the types of errors that has happened, what the impact of those errors has been on safety separation, and for each error that has occurred, a detailed review with the people involved, with the supervisors, the weather existing at the time to try to identify and so detail what led up to the error, and also where the human failed. We have categorized the types of errors that have occurred in perhaps 10 or 12 areas and from that come up with a set of framed changes for example, recurrent training, some emphasis on areas of training, such as the judgment area, which features very high in the air field. The changes of standardization and communications between the pilot and controller and between controllers, and we have seen a reduction in some of the errors.

We've also done a similar thing to the extent it's possible from the data bases that exist on various types of aviation and also air carrier accidents. And part of that involves a fairly detailed study of NASA's aviation systems reporting data NTSB data, our own aviation standards data base, which has some detail on general aviation-type accidents.

I mentioned earlier that one of the studies was looking specifically at the cuases of error in the general aviation area to see what factors were the primary ones in each accident that has occurred, and what we might do about it. And some of the related programs are looking at pilot judgment. What caused him to fly in the weather beyond his capability. So these investigations of what cause the accident then form the basis for the definition of programs to find a solution to prevent it from happening again.

In looking ahead to automation systems in the future, we go back to this same type of data base to see what the causes of human error were, what types of human errors have occurred, and to try to design the automation systems in the future in a way that we can avoid. For example, the aviation safety reporting system has identified that there are real cases on record where pilots have violated their altitude clearance. Some of those have caused incidents and accidents to happen. For example, there are several cases on record where the controller has cleared an aircraft to descend or to climb to an altitude. Pilot has read back the wrong altitude. Controller

didn't pick it up. Now, what one can do in that -- to address that type of problem is for example, to send to the cockpit a repetition of the altitude which was given to the pilot by voice, and perhaps also, a readback from the cockpit the numbers fed into the altitude alerter. Another thing that can be done, as we go to higher levels of automation is in the generation automatic real clearances for the pilot is to issue descents and climbs in areas that do not involve another aircraft immediately above or below the one in question.

So I think our human factors program across the board is trying to find out what the error types are, what causes them, and what we can do about them, and also to design around the fact that they're going to be with us as long as there are human beings. We can't eliminate them all, but can minimize them, we have to design a system in the way that's tolerant of them.

MR. HAY: Bob?

MR. NYSMITH: I'd like to answer that fairly generally because it seems to me the question is really inherently focussed on what we're here for. They ask a question if anyone has done an analysis on the totality of the problem and why isn't it available, why isn't it published. And it seems to me that in the situation that we're in we, NASA, the FAA and the government are a little bit today a kind of a hit or miss kind of approach, as working at specific problems as they come up. And I think that if, in fact, we did know what all the problems were, we wouldn't be sitting here today. And it seems to me that is a key point is that the thing we have to do from this point forward is really to put the totality of the problem in perspective and decide which problems really need the most attention. And it just hasn't been done, and I think that's where we have to go.

MR. HAY: Please C.O.

MR. C.O. MILLER: I apparently did not make myself clear, so give me a minute to get at it from another point of view.

Rocky up there knows that Armed Forces Institute of Pathology have a very fine think document that tells you how to approach pathological investigation of a fatality.

I can take mechanical engineering documents that tell you how to look for fatigue. What I can't find, with very few exceptions is a treatise which says you have an accident which presumably involves human error. How do you

approach this thing from an investigative standpoint so that you don't come up with a bunch of value judgments, which seem to be the rule in my experience when you take an engineer who goes out and looks at the problem. He'll take one approach. A physician will take another. A psychologist will take another. And I think all of us realize that these human errors are more often than not a combination of these factors. What I'm looking for is a protocol. I'm looking for a part of the NTSB investigation manual which says okay, if we have a -- what appears to be a human factors type accident, how do we go out and get into the details.

If anybody has done that, and put it together, I would like to hear about it. And that was the basis of my question.

MR HAY: Thank you C.O. Without encouraging John over here on my left from NTSB to make any statement, I would simply say that I'm aware that the National Transportation Safety Board at this time is in the process of re-designing and redeveloping the investigative outline in this particular area, and it is a question, C.O., as I would suggest to you particularly from your vantage point of many years of experience that the Board has the responsibility for the development and the determination of the causes in these areas.

They have a considerable effort going on at this time which I would rather defer to their direct discussion. Thank you.

Are there other questions please.

We have one on the left, and one on the right. I'm right-handed, sir.

MR SEXTON: George Sexton, Lockheed-Georgia Company. This is directed primarily to Bob Ettinger, and it's a two-part thing.

I'm wondering about the results and findings of the flight station design efforts. If they, in fact, find their way into new military aircraft, and if so, what is that method of transmittal to the aircraft builders.

MR. ETTINGER: I believe we're working on a design handbook in this area which covers the methodology that we've talked about. And that will be available to the industry. We can get you a copy of that.

MR. STREIMER: Irving Streimer from Cal State University.

I am bemused by a double point here. There seems to be a relationship or one implied between workload and fatigue. I don't know how to measure it,

and more importantly, I don't how how to measure it on an apriori basis. Are we to wait until there is a performance degradation, and then we say we overloaded the pilot. There are, I would assume, ways of indicating deviations from normal response patterns which would indicate that a pilot is overloaded.

The second point is I don't know if fatigue has anything -- I will retract that. I don't know if fatigue deals only with overload. We are making the assumption that the pilot comes to work ready, willing and able to work, which is the great American assumption, and many times he is obviously not able. How would you check this out before the accident and are there ways to do this and I would wonder if we are attempting this, why do we have to wait until the consequence has been realized?

MR. HAY: For the answer to this one, I'll start on my right and move across. Neal, first your response.

MR. BLAKE: I'd like your thoughts on this business of fatigue. It's not just fatigue, it's kind of the mental attitude that the pilot and the controller bring to the job in the morning. How do you check that out -- the fight with the wife the preceding evening, the divorce proceedings hovering in the background, and how that controls the pilot and the controller's ability to work?

And I'd like to hear from you and anyone else on a good way to sort that one out.

So are as workload versus fatigue, obviously the better job we do of designing the systems in the airplane and also on the ground, I think we could manage to level the workload out and tend to reduce fatigue somewhat. Just through the design of systems and the design of air traffic control procedures. But you raise a more interesting question. What do you do about the pilot who shows up fatigued earlier than the job standards would indicate. I think it's moveover in the medical department here so I'll pass to Dr. Reighard.

MR. HAY: Rick, if you would.

MR. REIGHARD: May I refuse?

Well, first of all, I don't know of any objective measure of the state of fatigue. And I think the gentleman who asked the question implied this. We

certainly don't have such a measure. As regards his observation concerning the fact that fatigue may not be solely the result of workload, I would endorse that concept. I think there are many, many factors that go into producing a fatigue state.

We can agree on certain things, mostly environmental things, leaving workload for a minute now that just per se. You don't have to be a researcher to come to a conclusion that they tend to contribute to a state which could be subjectively referred to as fatigue. And these are things like noise and other environmental exposures that stimulate the organism.

I mentioned as part of the presentation I made earlier the fact that we did some studies on FAA pilots. Flying, navigational aid checks, landing aid check missions, which would require them to near approach landing on numerous on duty days. The study compared both the subjective, and to the extent we could measure through stress hormones and so on objective indicators of psyiological demands, if not workload. Comparing those days on which the individuals flew with those days on which the individuals did administrative or desk work. And one of the findings was that the subjects felt more tired after the non-flying day than they did after a flying day. Now of course, as far as physiological demands is concerned as measured by the by-products of stress hormones, they were tired during the flying days, but we don't know now much of this, you know, has to do with state of arousal as compared to physical activity, this sort of thing. That hasn't been sorted out.

So I guess, I'm talking tangently in response to the question, I simply would reiterate by saying we don't have much of a handle on what fatigue really is. We can talk philosophically in terms of about of strain, namely, what do you put on the individual, what you might expect as the resultant thing called perhaps stress. But here again, how much is too much in terms of the flying task. We really don't know. We, except for the studies that we did on the FAA pilots flying their rather demanding missions, we have not done work in the area of fatigue. I think NASA has done some work, as a matter I've reviewed the literature extensively, and may be a better source of such information than we are.

MR. HAY: Thank you Rick. Bob Ettingher?

MR. ETTINGER: This is another subject which I'd like to duck too.

Your question brings to mind some sort of a microprocessor little hand-held game that you hand the pilot in the morning and he runs through this routine, and if his score is too low, you say well you're too tired or too overloaded and you can't go fly today. Get somebody else.

The real problem here is to try to measure the workload and quantify the result. The Flight Dynamics Laboratory has been working with a thing called the workload assessment device which is used on some of our experiments on the NT-33 that is operated for us at Cal Span. The pilot is given a four letter -- a set of four letters that are his, and then at different times during the flight these things flash up in front of him and there's a whole random series of letters that flash up in front of him. And if there's one of the set that he's supposed to recognize, he pushes acknowledge button. And if he's flying along in a low workload situation, he's got plenty of mental capacity in reserve here to go ahead and pick out his set. He does that on a fairly high accuracy. We start doing this in the flight pattern and he's in the flare, just ready to touch down, he doesn't do it as well. And perhaps something like that would lead to a way of quantifying the workload. The Aerospace Medical Research Laboratory is experimenting with measuring a certain portion of your EEG or your brain waves. You could wear this little skullcap with these little pins sticking into your head, a simulator and you could judge different brain wave patterns during different courses of flight. Perhaps that would quantify the thing.

Are you ready to sign up for any of those devices on a real time basis?

MR. STREIMER: Something was missing, probably my fault.

You are talking about fatigue and degradation and its effects on performance. I am talking about the fact that the performance requirement may never change, all systems work on expectations of behavior. The individual who came in ready, willing and able to work four, five or six -- and I was talking to a pilot earlier who has flown nine-hour flights, may not be the guy who started. And what I would like to know is what are we doing to assess contributory capacity as time goes on so we don't get surprised at the end. Why are we not directing research to send up flag systems that say this isn't the guy he was four hours ago. And there are ways to do this by simply examining

variations of input and output. That as the individual becomes fatigued and becomes less sensitive, response latencies increase, etc., etc. and etc. Why do we have to wait until after the accident? Why can't we develop assessment profiles during the flight?

MR. HAY: Did you want to carry on on that Bob?

MR. ETTINGER: No, I'm fatigued.

MR. NYSMITH: Well, I'm just trying to figure out if four ducks make a gaggle of geese or ducks or whatever. But I think the answers that we've heard and I could probably give others just about the same indicate that -- indicate that we really don't know the answer. And it seems to me that that's really the bottom line. If we could answer that question, once again, we would be a lot farther along. And that is a question yet to be answered.

MR HAY: I think as Bob said earlier in this presentation, and continuing that a bit further, and we're not sure right at this point in time if we're smart enough to ask all the questions, let alone answer them. And hopefully, one of the things that will come from these two days are proposals and recommendations and outlines and suggestions and documentations and all of the other back busting work that goes into putting these together submitted to us so that we will have the benefit of your well thought out considerations when you leave here today. Please avail us of that opportunity, if you would. The record will be open long enough for that material to be received and included in its final form.

There was another question on the left here. Sorry, I didn't mean to cut you off.

MR. PEEKE: My name is Peeke. I'm a pilot and a consultant.

Mr. Nysmith works for an organization, NASA, that seems to be after all the information they can get on pilot and controller errors, Aviation Safety Reporting Systems, or whatever. This is a system that guarantees anonymity for the reports, the controllers and the pilots can submit their many errors that they have made or that they've encountered. And it's NASA's job to guarantee anonymity such that they can -- you can feel free to report without any fear of retribution.

If you want all the information you can get, it's hard for me to imagine that the recent policy of Mr. Hay's organization, the FAA has been to largely

remove the anonymity. What I can't understand right now, is that is you want all the information you can get, and it would be anonymity that would permit you to get that information, from all the people out here and in the aviation community, maybe Mr. Hay could explain to us why they recently removed the anonymity provision.

MR. HAY: I don't believe the Administrator Bond removed anonymity provision of that. I believe in his recent testimony that he's given on that subject, that he made his point clear, that if it is something essentially that the agency has not seen itself, has not observed if the individual is not a repeater in this area, and I'm being very general. Clearly, the anonymity is deserved and exists. I don't believe that's exactly correct that it's been largely removed. However, I would be delighted to listen to any additional points you have on that.

MR. PEEKE: Well, the additional point is -- to be right specific, it's a one time only dispensation which means that if you file a report, you can only wonder whether the FAA is going to consider you a repeater, or if they consider the information valuable enough to grant you anonymity. On the other hand, when you file the report, you can't be quite so sure of those people back there or how they will consider your report. So it would be the safer thing not to do a report at all and that would disappoint Mr. Nysmith because it's the very thing that he wants to know. Even if I'm a repeater, let me go and repeat it ten times, if I'm a ten times repeater, he's all the more interested in me because that's the information that he wants. It just seems to me that there are people at opposite ends of the panel up there who have contrary goals.

MR HAY: Just one moment sir, I believe Walt Luffsey would like to comment, since this is a new policy area.

Please Walter.

MR. LUFFSEY: As regards anonymity I don't thing there's any possible way that FAA can access the naming of an individual reporting anything through the ASRS System. Am I wrong on that, Bob?

MR. NYSMITH: What I thought we could have is have Charlie Billings, who's the manager of the ASRS program really state what the position is. The point is, it is an anonymous system. We in FAA do not access that. I think Charlie can clarify that.

MR. HAY: Charlie, glad to see you.

MR. BILLINGS: Thank you gentlemen. Mr. Luffsey and Bob are quite correct. Whether it is one's first report to ASRS or one's 20th, one is, unless the report concerns a criminal offense or an aircraft accident, one is totally covered with respect to anonymity. The identification is destroyed by NASA as soon as the agency has determined whether it wishes to talk to the person reporting. We retain no record. There is no traceable record of the identity of any reported to the ASRS, and there hasn't been a breech of that in 26,000 reports. The questioner is correct with respect to the waiver of punishment extends to people on one occasion. Under the revised memorandum of agreement and revised circular of July 1, 1979. However, given that the FAA may or may not of an investigation of an occurrence, decide that a violation was involved, one can never by harmed by submitted the report to the Aviation Safety Reporting System because one's identity will never be revealed. The only record of that identity is the identity slip which goes back to the reporter. One cannot, therefore, be harmed by submitting the report regardless of whether or not a subsequent investigation determines that there was a violation involved. There is a lot of confusion in the community as a result of some of the happenings of a year and a half ago, with respect to these points. But I think the most pervasive confusion in the community, is between immunity which is a word the FAA didn't use and we didn't use for a considerable period of time. Actually a waiver of punishment or disciplinary action and anonymity. Anonymity and confidentiality have never been in question and are not now and there's no -- to my knowledge -- absolutely no intention of changing that in any time in the future.

MR. SPEYER: I'm Jack Speyer from Airbus Industry of Europe.

Coming back to workload, a few years ago there was a symposium on these matters in Germany. And it was stated that there was a need for a definition of optimum workload. Such that reliability and job satisfaction are assured.

My question is, is there any work being done in that field of optimum workload? And is there any hope that such a definition might be possible.

MR HAY: Dr. Reighard, would you make the first pass at that one please.

DR. REIGHARD: As I think I indicated or inferred, certainly in the FAA medical research area, we have not approached the matter of optimum pilot workload to the extent that any inferences can be drawn from the work we've done with the controllers using simulated systems. Yes, I think we may have gotten involved there, but we don't yet possess the kind of information that would allow us to write a prescription for optimum workload even for controllers.

I guess I'd have to pass as far as pilot workload studies are concerned. I do believe that NASA at least historically has touched in those areas.

MR HAY: Bob Ettinger, would you take a look at that from the military standpoint please.

MR. ETTINGER: I think I'm still fatigued, that really falls outside my area of expertise. I think there are some people here from the aerospace medical laboratory who may have some answers in that area.

MR HAY: Bob Nysmith?

MR. NYSMITH: What I'd like to do is ask Dr. Al Chambers from Ames who heads up the Ames human factors area to briefly cover what they are doing in this area.

MR HAY: Thank you. Al, please.

DR. CHAMBERS: Let me first speak to the use of the work optimum. We're certainly not looking at an optimum workload, in fact there may not be an optimum workload for all situations for all operations.

What we are trying to do is better understand how to measure workload through the use of secondary tasks or through the use of other types of measures, time estimation that will in subject questionnaires which I think were talked about in Neal's presentation earlier will give us a little better hand up on what the workload is. Maybe at that time somebody can define what optimum means and how it fits in here, but we're certainly not doing that.

MR HAY: Yes, please.

MS. KITAY: Deanna Kitay from Texas. Cliff, when we talked a month ago in anticipation of this meeting you said there'd be no holds barred. Is that correct?

MR HAY: That's correct, of course.

MS. KITAY: The question's not to you, it's for the Colonel. And it was a question before he addressed this group, and now it is specifically addressed to him.

I was going to ask you sir, if you would care to comment on the extensive work done by your own Lt. Colonel Robert O'Donnell in the AMRL group and in coordination with Hardman in San Antonio with respect to workload and fatigue.

Did you want to comment on that before I finish my question?

MR. ETTINGER: Well, I'm not familiar with that work so I have nothing to add.

MS. KITAY: Well, to the individuals asked with respect to this you might wish to inquire of the AMRL group at Dayton, Ohio because the program is funded considerably for, I think it's projected for 10 years to specifically look at this question. While I won't research the authority of Col. O'Donnel to do it, I would refer you to that because I think it is excellent work. And it's done in conjunction with the group in San Antonio. But my point about no holds barred was I do think there is a lot of research that has been done by university groups, particularly by the military around the country. There's been a lot of money invested in research programs and I think here is a group today and if we are to take this symposium seriously is to ask about that and to inquire about it. For example, with all due respect to the Colonel, I think we do a disservice when we discount such things as little black boxes and gizmos or needles and pins, which is not true we don't stick needles or pins in the scalp. But I think, it we assume an attitude, would you like to be the first to try it, we do a disservice to basic research investigators who would then in turn would be of service to the implied scientists.

So I would just like to call you on that Colonel, and with all due respect having no holds barred I think we need to look honestly.

MR HAY: And, it's a matter of record. Thank you.

Neal, you had a followup statement that you wanted to make on the previous question.

MR. BLAKE: Again, turning back to some of the work we've done on controller workload, getting back to what's an optimum workload and have to extend that to say what are the right functions to automate, for instance,

which function should be retained by the controller, It's clear from looking at when the systems errors occur, when the controller is lightly loaded there is a tendancy to think about other things or discuss matters with your companion controllers, and there's an incident of errors under conditions where you normally wouldn't expect them to occur.

The other extreme is noticed when the workload is very high, the controller is near saturation and the high workload may be increased momentarily by one or possibly two potentially conflict situations developing on top of each other. And at this time the focus on the work task seems to narrow down to the one or two immediate problems with a tendency to let some of the aircraft perhaps get a little farther out of control than one would like.

Also the type of function is important. Functions the controller does the best at are ones where he derives some satisfaction from a job well done. For example, if the controller is able to space aircraft accurately over a prolonged period of time to keep the landing rate up, there's a fair amount of satisfaction in that task. Representative of the type of function the man is extremely poor at is one of monitoring, monitoring anything. And we have a position at some of our airport control towers for parallel approaches where two controllers are assigned the position where their total job is to monitor approaches on two parallel runways looking for the extemely rare deviation from the course. Span of attention is very good for about 20, 25 minutes and then lapses rapidly as to that period of time.

So, in trying to define the level of workload as near optimum as we can, it's very clear we also have to be very careful about which functions we give to the machine as well as to human. And I think one would find very similar things in the cockpit type of study which we hope to run later.

MR HAY: Thank you Neal. Other questions please.

MR. BERTONE: Bert Bertone, Sikorsky Aircraft.

I'd like to address this to Col. Ettinger. In light of the fact that the Air Force may be looking for new helicopter in the near future, what is your office doing about helicopter research and the development of side arm controllers or CRT's for the helicopter.

MR. ETTINGER: Right now, nothing. My office is a very limited part of the Air Force effort, but to my knaoeldge, there's nothing going on in the

helicopter area. We do have a lot of experience with side arm controllers, and I don't believe there's any unique problems to helicopters with side stick or side arm controllers that we don't have some experience with with airplanes.

MR HAY: Thank you, Bob.

Other questions please.

MR. HOWARD: Jack Howard from the Aeronautic Products Association for Neal Blake.

Neal, in your presentation it indicated that there's an effort in the FAA to develop some subjective workload ratings. And my question is that if that effort is successful and some kind of a rating is developed, would you please comment on how you expect to use it. More specifically, who would you ask to complete these ratings, when would you ask them would it be -- would it include the line pilot or would it be limited to the test pilots from the aircraft corporations or FAA individuals or use during simulator evaluations. Just how would that rating system be employed.

MR. BLAKE: I think that's about twelve questions, Jack.

The answer is yes, we are trying to get better workload measures. The one I mentioned that MIT has been developing, is somewhat broader than the original stadnards, and I think you folks are involved in that effort. In that it tried to include more of the tasks the pilot does other than just flying the airplane and specifically the air traffic control related tasks to give a more faithful representation of what the total pilot workload is in a real operational system. It's our intent to take that particular set of workload subjective workload ratings and test them at NASA Ames, and we hope that those tests will start fairly soon. They'll be run initially with airline line pilots. There probably will be no test pilots. But a few of us FAA official may go out and participate in some of the simulation runs merely to form our own opinions of how well those rate of systems are working. Primarily the emphasis will be on the airline pilots. And if it's successful, we hope to gradually upgrade the standards and use them in evaluating changes perhaps to the air traffic control system or to the cockpit automation.

MR HAY: Does that answer your question?

MR HAY: Other questions please.

MR. ALKOV: Bob Alkov with the Navy Safety Center.

There is currently a great body of research being done on stress medicine on the effect of stress on health changes. Stress coming from personal problems, divorce, death in the family, that sort of thing. Is anybody looking into this problem. I ask this because we, in the Navy have been.

MR HAY: Dr. Reighard, would you please.

DR. REIGHARD: I'd like to refer to the study I mentioned during my earlier presentation, the Boston University study on health change and air traffic controllers. This study as I indicated lasted for a period of five years, it involved a three and a half year period during which all study subjects were medically examined, comprehensively examined medically at least five times. More importantly, a month questionnaire concerning any circumstances that changed, including domestic circumstances, health status and so on, a monthly questionnaire during the entire three and a half year period was filed by each subject. Such that the matter -- and this, by the way, will include financial change, change in domestic relationship, including divorce, separation, loss of children, this sort of thing. So all of that was included. It's a very voluminous report, many, many pages of data, and the operational people within FAA have found it so massive that they haven't been quite able to digest it. We're trying to remedy that situation by getting a condensed summarized version that hopefully will be available to basically non-scientists personnel.

I'd like to say that with regard to the question of does the job of air traffic control produce health change. The answer is basically no. It was true that the study identified a larger than expected number of persons who has elevated blood pressure or even went on to develop hypertension that one would expect in other populations, but the study summary said that this could in no way being interpreted as this being a product of the job. It was felt that hereditary factors, perhaps, or perhaps even some selection factors, getting people who were predisposed to developing this kind of reaction may have caused larger numbers to be found in the controller work force. One thing they did definitely establish and that is that they could predict with a high degree of accuracy who was going to be a condidate for later development

of high blood pressure or hypertention simply by observing his blood pressure reaction to work. This doesn't mean excessive work, it just means when he was on the job if his blood pressure rose to a significantly higher level than his fellow controllers, he was more likely to develop problems with blood pressure at a later date. So I guess in summary I would say, yes, this is a very comprehensive study, there's never been a study that's been so inclusive of all factors that might be related to health change, including work and outside work factors. There's never been so comprehensive a study that's ever been performed.

MR. ALKOV: Any plans to extend this into the air crew error regime?

MR. REIGHARD: We have no current plans to extend this into the air crew error. When I say we, I mean the immediate plans or the projected plans of the Office of Aviation Medicine.

MR HAY: Bob Ettinger, do you have any comments on that?

MR. ETTINGER: No.

MR HAY: Okay.. Bob Nysmith for NASA?

MR. NUSMITH: No I really have no comment. We really don't have any work in this area.

MR HAY: Does that answer your question sir?

MR. ALKOV: Yes, thank you.

MR HAY: Are there other questions? Yes.

MR ANDERSEN: I'm Jim Andersen from TSC.

This isn't a question, but rather a request of Dr. Reighard.

I saw in some of your testimony, not too long ago, that the -- you people have taken over the thousand aviator study that was started by the Navy in World War II, that had become obsolete because those people who are in that data base are of no more interest to the Navy but become a very valuable data base to look at the mandatory retirement, because those people now are quickly approaching age 60 or have passed it. Can you talk about that at all?

DR. REIGHARD: We have for a number of years contributed funds for the continuation of the 1,000 aviator study. It's never been an amount sufficient

to continue it in the comprehensive manner that that study ought to be financially supported. We just never had the amount of funds. With the diminished interest on the part of the Navy to provide funds, as a matter of fact, I believe the Navy will shortly make a determination not to provide any funds. Historically, the medical research budget of the FAA has never been anywhere near able to support that, and as a matter of fact I hesitate to comment on my belief of the surrent situation, I believe that it's entirely possible that for this fiscal year, we will not have any funds to contribute to that study. An assessment was being made when I left Washington a week or ten days ago in a series of trips or meetings, but I believe it's possible that for this current fiscal year, we will not be contributing to the fundings. We have encouraged the Navy to approach such agencies as the National Institutes of Health. We, ourselves have approached the National Institutes of Health, and I don't think they should be written off as possible sources of funds. I agree with you. This group of pilots, first studied in 1940, here it is now 1980, are in their early 60's and it would be very very -- well, it would be a shame if the results of past studies couldn't be compared into the future on the same subject. But as far as FAA is concerned, I think we're going to be a minimal part of the determination as to whether that should go on.

MR HAY: Thank you.

Jim, does that answer your question all right, fine.

Are there any questions please?

MR. LAWTON: Russ Lawton from AOPA.

I guess maybe I'd like to start for a moment to go on the record to sort of express a little disappointment after going through the program since when we started out it was pointed out that in general aviation human factors problems or human error account for 80 some odd percent of the accidents and that it would be users on this panel, manufacturers and all aspects and when I get to the users part, I see the airlines, and when I get to the manufacturers, I see the commercial aircraft manufacturers and I'm a little disappointed that general aviation wasn't given some consideration in that regard.

So I'd like to start off there. My question, and if somebody at FAA could enlighten us a little bit about the coordination between FAA and NASA concerning some of the programs going on at NASA, which relate to general

aviation vis a vis the single pilot IFR study and some of the other studies of the AFRS program, since there seem to be some very relevant things going on there that we'd like to see the FAA carry through while they're ongoing.

MR HAY: I'd like to simply respond to the first part of that. If you'll bear with us for the two days, you'll hear more discussion on your concern and it's one we all are sure on the scope of coverage. Particularly in the general aviation area. And you heard Walt get into that in his early comments here. There will be a further discussion toward the end of the second day.

For your second question, if I may turn to Neal Blake to start off on that one.

MR. BLAKE: On the area of joint programs, we have about 26 program areas now in which we have joint program definitions or tasks or agreements to coordinate efforts between ourselves and NASA. And a lot of them are in the safety area. And I believe we have very good cooperation, very good understandings and periodic exchanges of information on most of these programs. And usually on each side, the NASA and the FAA side, there is a person designated as the contact or the coordination point. Periodically, some of the more important topics are brought up to the coordination meeting which meets generally every six months.

Perhaps Bob would like to add to that.

MR HAY: Please Bob.

MR. ETTINGER: Well, I'll just reiterate what Neal said.

We have quite a busy activity with the FAA in coordination. We do it at several levels. In Washington we have a special management group that really meets quarterly. A lot of time, more often than not, on more of an informal basis. And at the Centers the FAA has more of a liaison officers at the research centers, and there's a lot of the communication that takes place at the working level. We try to make a specific point in NASA to make sure that coordination happens.

On the other hand, I do want to make sure that I make the point that we do, even with all of this coordination, maintain a certain independence and objectivity in that regard and I think the FAA expects us to. And when we talk about specific programs and whether or not the FAA will followup on

something we've done, we normally make a decision somewhere down the pike on our programs, a joint decision with the FAA on how it can be phased into their end of the game. I think that the programs that we do and that they do are totally known by both of us and that there is an extremely good working relationship.

MR HAY: Just a follow on to that. We have Harry Verstymen in the audience here, who heads up the Langley Office of the FAA, and it is that focal point for coordination at that center.

We have Jack Cayot at the Ames Center, in San Francisco, where the same type of coordination is carried out on the spot by the people daily.

Are there other questions?

We have two approaching. Please continue, but let's see, how about you first.

MR. TAYLOR: I'm Hank Taylor, from the University of Illinois. I'd like to continue our present discussion just a minute. I know that the coordination between the FAA, NASA and the Department of Defense in the human factors area has significantly improved during the past several years. But I would like to point out that during my tenure as the person in charge of the DOD human factors program until about 1978 for about six years, I'm a little concerned that the people from the Washington area in charge of this program are not represented here, today. I think that in part represents some of the questions that are being asked about the military program simply can't be answered and it's no fault of Col. Ettinger in that regard. There are several points of contact for both the human factors and the medical programs which are funded at a substantial level by the Department of Defense, and if in fact these people are not involved in your present planning exercise, I would certainly highly encourage that these contacts be made so that the program is a fully integrated one across the federal government. This program has a single representative here from DOD, we have visited all of the services so we might have had them all represented here.

MR HAY: We have a question here.

MR. SHERBERT: Yes, Archie Sherbert from Boeing Vertol Company.

I believe rotary wing aircraft are becoming more and more significant in

the non-military aviation population. Yet looking at the list of attendees, I recognize only five or six people out of 160 whom I select as being totally dedicated to rotary wing and that's a pretty small number, I hope it's not indicative of the interest.

I would like to ask the FAA and NASA panel members to comment on what percent of their total human factors R&D resources are dedicated to rotary wing peculiar tasks.

MR HAY: Bob Nysmith, would you care to begin on that?

MR. NYSMITH: Let me make a comment -- the followup on one of my previous questions when I talked about the coordination between us and the FAA. I did not mean to imply that we thought things were all perfect and everything was funded just at the right levels. I guess my basic view is that we do need to expand the work in the area of human factors. Perhaps it's fortunate that the Ames Research Center is the lead center within NASA for Rotocraft technology. I don't know how much money today we are putting into Rotocraft Human Factors, but I suspect its a small level. Mel or Al, do you know how much we are putting into Rotocraft Human Factors?

MR. CHAMBERS: I think the dollar portion would be about one fifth of the total program. The manpower loading would be more like a quarter to a third of the program, probably a quarter.

MR HAY: Thank you, Bob. If I could just mention to Arch, we have in the Special Programs Division in the Office of Aviation Safety the Helicopter Operations Task Force monitoring as one of our special programs. The individual who handles that is Harlin Hosler in my division. On my left over here you will see Bob Wedan, Mike Nelson and others who are the ones who develop the program plans and conduct the work in this particular area. I think that it's an emerging interest that we have, and that the program is well under development at this point. I might just ask either Bob or Mike if they would care to speak to this subject just for a moment.

Bob Wedan, the Director of Research and Development.

MR. WEDAN: Thank you. I was just checking the numbers with Mike Nelson here who is program manager of the R&D activities. The scope of our activities covers a fairly wide range of subjects. It's oriented toward IFR

operations so it gets us into air worthiness aspects, route structures, navigation communication, and things like that.

The total program over a five year period is of the order of about $13 million. That's what we spend, but this is a small part of the total effort; and I might point out that we're very closely coupled with not only R&D work within NASA, but also the Department of the Army which happens to be the biggest user of helicopters.

So there is a lot of money going into it. So our $13 million is not representative at all of the big effort. But within the FAA, we estimate approximately 25 percent of our resources are going specifically to human factors problems.

MR HAY: Thank you Bob. Arch, do you have any other questions on that?

MR. TYNCZYSZYN: I am Joe Tymczyszyn, Jr. I am a staffer on the House Committee on Science and Technology. We are the authorizing committee for FAA R&D. I'd like to make sort of a statement or give a thesis here. It is not particularly pleasing to me, but I'm afraid it may be the truth that despite the workshops and the interest we see of all these people, the amount of money that FAA has to spend on human factors in the future may well go down. The reason I say it may go down in watching FAA budgets in the past. I think for many, many years with few exceptions, FAA/R&D money has decreased in real dollars after you include inflation.

It will probably continue to do that in the future if past trends continue. And we also see coming down the pike the ATC computer replacement. And that R&D program is going to soak up so much money that things of much higher priority than human factors are going to set send down the tubes.

So I am just wondering what the FAA comments on this are. I am not happy to see it but it may be a reality. Let me ask a question to everyone in the audience. If anyone here belongs to an organization that's planning to lobby for human factors research, I'd like them to stand up. By lobbying, I am talking about The Office of the Administration, the DOT secretary, the OMB, the Congress, including the appropriations committee. Does anyone here belong to an organization that's planning to lobby for more money for human factors?
ization that's planning to lobby for more money for human factors?

Well, that's reasonably encouraging: but I really would state that FAA by itself does not have the clout to increase its human factors budget. And if you want to see more money in human factors, outside organizations are going to have to go to the Administrator, to the Secretary of Transportation, to the OMB, to the Congress including the authorizing committees and the appropriations committees.

Without a large number of ouside lobbyists, despite all of our workshops and everything else, the money is going to go down hill; and we are kind of wasting our time talking about it here.

MR HAY: Joe is always right to the point. Thank you. Neal, would you care to comment in any way on that?

MR. BLAKE: Joe, we were just about to come up for some more money. I think the whole purpose of the workshop is to get the public's perception of what we should be doing in the human factors area, to look at the program that we've been discussing across the different agency, and to come back and say here are the areas where we think you ought to augment that program, and here is about the level that you should come back and ask for.

Now, it's true that we have to get on with replacing our computers and our communications systems and everything else; but it's also clear from looking at the accident data that the one thing that's at the head of the list every time is human error. And we have to spend enough money in that area to get it under control, to consider it both through improved training and through building the automation systems of the future. We have to put as much priority on that as we do on modernizing the rest of our plant. Perhaps more.

MR HAY: Thank you Neal, Are there other questions?

MR. TYSON: I am Chuck Tyson. I am with Essex Corporation. I'd like to just make a comment on Joe's comments, and that is that I spent a few years working with systems development as a human factors specialist. If you have an air traffic computer or system replacement, it would be insane to have that work go on without integral employment of human factors technicians and a major component of that air traffic control system development.

So when you say the air traffic control computer replacement is going to suck up all that money, it frightens me to think of a computer program being

developed which is going to require people to operate it and maintain it and for someone to think that human factors people would not be involved in that program very, very importantly.

MR. BLAKE: We certainly agree with you, and a lot of the efforts for future automation program are very much in the human factors areas. We've talked about some of them, the type of functions that should be automated, the optimum levels of workload, the appropriate display interface with the controller, and many other related issues that are tied to the airborne end, what should we put on the data link to the pilot, how should it be presented, how should we combine the information from a number of new automated functions in order to present them properly to the pilot to reduce his workload and make it affective for him. We cartainly agree with that.

MR HAY: Are there any other questions?

UNKNOWN SPEAKER: I hate to be a repeat offender here. With regard to some of this human engineering that goes into airplanes, at least the ones that I am familiar with, it seems like a lot of money is spent in the design stages of the airplane, putting a lot of elegant black boxes in, flight directors and that sort of thing; but when it comes right down to it, several years after the airplane has been introduced, it turns out that people only use maybe 25 percent of all those neat things that were designed at great expense into the airplane.

I think maybe a factor that should be considered is when you design a piece of hardware to make sure that you consult the ulitmate user, not just the engineer who is going to design it in a conversation between the human factors practitioner and the design engineer; but to make sure that you somehow talk to the ultimate user, not even the supervisory fellow, but the follow who is going to make his living with the machine so that you don't design into it something that he doesn't want even though the engineer knows how to do it and the human factors fellow says that's a great idea. If money is in short supply, that's maybe where you can save some. Just don't put in the boxes in the first place.

MR HAY: A good point, one that I would ask Ron Lowry and others to address on Tuesday as they start there AIA session because here you will be speaking to the people who make the original committments for the aircraft

design and the equipment with it. So with that I will now defer to AIA and their portion of the panel. Yes, Neal, please.

MR. BLAKE: Well, that works both ways. Back in 1962, we said we were going to automate the air traffic controls system; and, of course, one has to have a display and data entry device for this. So we made some mockups of various and sundry control positions, and then we got down to the detail functions that were necessary; and we invited the controllers in and said here are the functions we think you will need. Then they started, "Where is the ---?" "Where is the ---?" "Where is the ---?" game; and we ended up with keyboards up one side and down the other side and across the front. But the rather interesting thing is to go back now some 15 years later and have the computer bookkeep how many of those keys were actually used. So there are two sides to the story.

If you get a lot of controllers and a lot of pilots together, they have different views; and you end up with a lot of functions. And it takes time sometimes to sort out the ones that are really key. But I think you are right, and that's why we have a lot of airline pilots participate in our simulations on some of the new functions to try to get right at the problem you are underlining. Those systems have got to be nearly automatic with a minimum of required pilot interaction or they are not going to be used.

MR HAY: Thank you Neal. C.O.

MR. MILLER: When I was in the cockpit design business about a hundred years ago, we had a saying that I think is still good. It simply is that the pilot is the worse possible person in the world to design a cockpit. He is the only person who can evaluate it.

In this regard, I would like to pose a question to Mr. Blake or anyone else connected with the FAA. In terms of how do you go about mustering a team to do this design work whether it's an air traffic control system or whether it's a cockpit or a thing that has to do with human operation because I think the gentleman from Essex a moment ago brought forth a very important point and I am not sure if everygody got it.

At least my interpretation is that, look, you better be careful what kinds of people you get into this basic design tasks. We learn, I think, the hard way in cockpit design that you don't take a good mechanical designer or a good

electrical designer or a good power plant designer and ask him to come up and design the flap system or the engine instruments or maybe the generator display.

You have some -- usually a team approach of people who are qualified in not only human factors as I think most of this group understands it, but in the individual systems. I think the design approach, getting the right skills at the right time whether it's writing requirements or actually doing the design. It's essential. I am curious because I frankly don't know who is flight standards approaching this problem because I know as of not too long ago there wasn't a single qualified human factors person in flight standards in my judgment.

MR HAY: Neal, would you care to address that initially? Or we have Craig Beard sitting off on our left. Can you take just a moment, Craig? You'd rather not? Allright.

MR. BLAKE: Well, perhaps I could, If you'd let me deviate from picking on Flight Standards or Aviation Standards here because I am sitting beside one and I might get clobbered.

We have the very problem that you mentioned every time we want to put in a new piece of automation into the system. First of all, if it doesn't fall within one of our five goal areas of improving safety, performance, productivity, and protecting the environment and saving fuel, it doesn't happen, or solving a problem that exists in the current system.

We have had a great deal of argument in the past about who was in charge and who should do what and with which and to whom and when. So we have taken to appointing diagonal sliced groups which cut across all the disciplines, air traffic controllers, facility installation technicians, reliability people, engineering, human factors, and so on; and sit them down in a group to try to define the requirement for the new system improvement. Then we use the engineering staffs augmented with specific special skill as necessary to produce the device.

Then we call back in the diagonal slice people to sit down and evaluate it first of all in a test environment well away from the day to day operation where we can really stress that particular improvement under some of the worse traffic conditions and emergency conditions that go well beyond what we hope we'll ever find in the real world.

Then, and only then, does it go into an operating facility for test. We certainly agree with you that it takes a very broad spectrum of capabilities particularly when you get into higher levels of automation where so much of the design is tied to human capability.

MR HAY: C.O. you've had the last question, and Neal you have had the last word. We thank you for your attention and your participation.

AFTERNOON SESSION

CAPT. PRYDE: Good afternoon, the Airline Pilot Association welcomes the opportunity to join this distinguished group in the quest of solutions to what we perceive to be one of the major problems facing the air transportation system. And that is the human factors of our airline operations.

We are part of the guinea pigs, we are part of the humans as a group who will perhaps be studied.

I have with me today a group of highly experienced airline pilots and staff members and we prepared a program. I'll give you a brief outline of each subject and introduce the panel.

Captain Bud Leppard, who is the Airline Pilots' Association Chief accident investigator that handles the accident investigation team and is a captain for Eastern Airlines will address the subject of pilot error as probable cause.

Captain Don McClure, also an Eastern pilot with the National Accident Investigation Team and a specialist on flight recorder and voice recorder interpretations will address the subject in flight data acquisition and analysis.

Captain Bob Smith who is the Central Air Safety Chairman for the United Airline pilot group, will address fatigue, workload and stress.

Captain Bob Mudge, who recently retired from Delta Airlines. He has been a long time worker in the ATC and the ground to air communications field will address the command cockpit resource management.

Captain Jack Howell, who is the Executive Central Air Safety Chairman for the Air Line Pilot Association and an Eastern pilot will address the pilot ATC environment interface.

Mr. John O'Brien, who is the manager of ALPA Air Safety and Engineering, Washington, will address the certification problems and solutions.

And without further ado, I will turn it over to Captain Bud Leppard to address the pilot error and probable cause.

MR. LEPPARD: Thank you Gerry.

I have just reviewed Public Law 93-633 which in 1975 established the National Transportation Safety Board. Since the personnel employed by the Board could make such a direct contribution to the reduction of human factors accidents, I am sorry that they are not represented with a panel at this workshop.

I am happy to see Mr. Gerry Wallhout in the audience however, who is the Chief of the Human Factors Branch of the NTSB.

Human factors comprises a large slice of the probable cause pie. The Safety Board has a direct mandate from Congress to reduce the likelihood of a recurrence of similar aviation accidents through, among other things, special studies and investigations. Yet, there is rarely an investigation done in the human factors area. The National Airlines Accident in Escambia Bay in Pensacola was clearly a human factors accident. Yet, no study whatever was conducted to determine why the crew behaved as they did. Even though both pilots testified under oath that they misread their altimeters, and even though reams of material exist on the subject of human inability to rapidly and consistently read certain types of altimeter, much of this information generated by the FAA, by the way, this area of the investigation was completely ignored by the NTSB. The Board did an excellent job of pointing the finger in this report, but the word recommendation is not even mentioned in the report. As a matter of fact, the survival of the crew, and their subsequent testimony seemed to prove an embarrassment to the NTSB, because their testimony did not support the NTSB's preconceived notion of the probable cause. Consequently, the testimony of the crew was almost totally ignored, and the NTSB went ahead with their conception of the probable cause. The potential for avoiding a similar type accident through detailed human performance study was lost.

Previous to this accident, a surviving crew member of an accident in Charlotte testified under oath that he misread the same type of altimeter as that installed on the Escambia Bay aircraft. His testimony again conflicted with the NTSB's desk-bound concept of the probable cause, so the crew testimony was ignored, and the opportunity to prevent the Escambia Bay accident was lost.

There have been many other accidents or incidents in which altimeter misread has been proven or suspected. Northeast at Martha's Vineyard, American at Cincinnati, SAS at Los Angeles -- I could go on and on. There certainly have been enough of these to indicate an equipment design problem. Yet the NTSB has firmly and consistently refused to admit that the problem exists. It is so much easier to call it pilot error and go home.

In 1977, ALPA held a symposium on human factors in Washington. Mr. Jack Shrager, who wrote a definitive paper on human error with regard to altimetry, was present at that meeting. Yet the FAA prohibited Mr. Shrager from presenting his paper, and he had to have a military co-worker present it for him. We cannot understand the great reluctance of government agencies to address and confront equipment design deficiencies which have repeatedly resulted in aircraft accidents and great loss of life. Sure, pilots misread altimeters, more often than we care to admit. But does anyone out there who has the power to do something about it care enough to ask why?

I have many human factors type accident reports in my files in which the research section is covered in its entirety by one word -- none. That is a sad commentary on our inability to admit to human frailty, and our unwillingness to seek out its root causes.

I suppose there is a certain amount of self satisfaction in pointing the finger at another. But pointing the finger, even though sometimes necessary, is the easy part. Making a determination as to why a person made his mistake is the difficult part, and because of this, it is generally not even attempted. But until the NTSB human factors group does more than document how and where the bodies fell, we will continue to have a disproportionate share of human factors accidents. Perhaps the human factors group is doing what it should be doing. Perhaps we need a new group classification called the human performance group. Just as it is essential that the Chairman of the Aircraft Performance Group be steeped in aircraft performance engineering, it is essential that the chairman of this new group have a firm background in psychology, human performance, and human error analysis.

Until the human failure area is realistically addressed, human error will continue to be our largest cause of aviation accidents. Perhaps even then, it will continue to be so. But not to try is not to do.

ALPS is not alone in its feeling that the human performance area has been largely disregarded. As Mr. Chuck Miller, who is with us today, and who was former Director of the Bureau of Aviation Safety, the NTSB, succinctly put it, "Unfortunately, the only evaluations of the human factors investigations appear to have occurred through the media and public meetings, rather than professional discussions among investigative parties."

Dr. A. Diehl, former Senior Air Safety Investigator, Human Factors Division, NTSB, now with the FAA, and also with us today, stated in a paper in June of 1980, "Almost all current field investigations and most major investigations fail to adequately emphasize human performance questions."

There seems to be a consensus in the industry and the NTSB that the pilots are uniformly opposed to in depth investigations into human performance failures in accident situations. Nothing could be further from the truth. For the 16 years I have been involved in accident investigation activities, we have begged for more attention to the why of an accident, as well as to the who. We have these meetings, and we talk about it a great deal, but no one who is in a position to do so seems willing to take the bull by the horns and do something about it.

We often find that even though the pilots are the primary users of the aviation system, and even though every airline pilot has not eight to ten hours, but thousands of hours of experience, in using the system, our comments and suggestions often result in actions being taken by government officials which are in direct conflict with the results desired by the pilots. Perhaps we should take the rabbit in the briar patch approach, and say, please, Mr. King, don't investigate human performance in the accident, then perhaps some progress would be made.

Since my area of interest is accident investigation, most of my comments this afternoon have been directed toward the NTSB. But since the FAA is sponsoring this workshop, I don't want to ignore the contribution that you have an opportunity to make in the human performance area. In nearly every accident in which human error is suspect, certificate action against the pilot is taken by the Administrator. It is obviously self serving for us to suggest that this is not the proper approach, and I frankly do not pretend to know the answer to this problem. But what I do know is that since a pilot who is in-

volved in an accident situation knows almost for certain that he will soon be the recipient of that dreaded letter from the Administrator, his discussion of his performance is severely inhibited, and the opportunity to profit from his misfortune, and prevent a similar type accident is lost. This is a question I believe the FAA should come to grips with.

It is difficult for me to stand here and say that transgressions which result in accidents should go unpunished. Yet, speaking strictly from an accident investigators' viewpoint, it is obviously that much vital human performance information is being suppressed through the crime and punishment technique.

The Air Line Pilot's Association urges your cooperation in establishing a human performance study team in each accident in which human failure is indicated.

Areas which should receive thorough study should include, but not be limited to medical factors, operational environment factors, behavioral factors, and, very important, equipment design factors.

Let's start by admitting that a mistake was made, but until we find out why, we have not fulfilled our primary responsiblity in accident investigation-that of preventing a similar type accident through research and recommendations.

All of you here today are involved in air safety, but are you just giving it lip service or are you really dedicated to improving it? There is a real difference, you know.

The chicken who provided the egg for your breakfast this morning was involved in your breakfast, but the pig who gave you your bacon, he was dedicated. Think about in which category you belong. Thank you.

CAPTAIN PRYDE: Here, again, I think we'll continue the process of speakers this morning, and hold your questions until all the panel is finished.

And also I failed to introduce one of our contributors, Mr. Bill Edmunds, who's a staff engineer and human factors coordinated in the office staff. He'll give you a presentation on the air safety reporting system.

Let me introduce Captain Don McClure, who will handle in-flight data acquisition and analysis.

MR. McCLURE: Good afternoon ladies and gentlemen, it's a pleasure for me to be here.

The subject I am about to discuss is one of great importance to all of you, and I hope it can provide some useful information in the future, establishment of the human factors data base in aviation safety.

In-flight data, where does it come from now, and where will it come from in the future? Presently, flight data is recorded on flight data recorders, digital flight data recorders, cockpit voice recorders, and some airlines have partial use of ACARS, automated communication and recording system and AIDS, airborne integrated data systems. In the future, cassettes from flight data acquisition units, advanced AIDS and ACARS, and as money and technology permit, virtually any bit of information desired could be telemetered to the ground from operations aircraft. Obviously, the real problem will not be acquisition, but data reduction and analysis.

At the present time, approximately 2200 aircraft or 86 percent of the U.S. air carrier fleet are equipped with the archaic scratch type foil flight data recorders. These recorders by law only record four parameters, altitude, airspeed, magnetic heading, and vertical acceleration. The remaining 14 percent of the fleet, wide bodies aircraft, are equipped with the digital flight data recorders. These recorders by law record a minimum of 14 parameters.

The present day cockpit voice recorders on U.S. aircraft record four discrete channels, the captain's audio panel, the first officer's audio panel, the cockpit area microphone, and the second officer's audio panel or cockpit P/A.

What happens when the data from the present day foil recorders and CVR's is collected and analyzed. No better examples of the misinterpretation of this data are available than in the examination of a number of botched NTSB accident investigations. I might also add that the FAA, as well as ALPA participated in these investigations. There is no better place to learn from our mistakes in aviation than the accident.

I am sure everybody remembers the Charlotte, North Caroline, September the 11th 1979 and Pensacola, Florida, May the 8th, 1978. The CVR from the Charlotte accident was the basis for the conduct of the NTSB investigation, resulting in a probable cause accusing the pilots of talking too much, therefore, losing their altitude awareness. It took the NTSB CVR group

approximately one week to complete the CVR read-out. An additional one year of work by ALPA produced a CVR transcript with 59 addition operational items, not included by the NTSB. I will be the first to admit the pilots made a mistake. They misread their drum pointer altimeters. The question neither the FAA or NTSB asked was, why did the pilots misread their altimeters? Even the NTSB could not figure out why the flight data recorder had the Charlotte aircraft 450 feet low at the final approach fix. The altimeter misread information was made available to the NTSB the day the public hearing commenced, however, they ignored it then and subsequently in a petition for reconsideration. The crew of the National Airlines Boeing at Pensacola admitted they misread their drum pointer altimeters.

The Charlotte Captain made specific statements on the CVR about being tired, a fatigue study was done by the then FAA chief of aeronautical applications division, Dr. Stanley Mohler who is with us today, and if I may I would like to read from that the information that we did present to the NTSB and their response.

Under the aspect of human factors, the problem of misreading altimeters has been with us for many years. ALPA, at a pre-hearing conference, attempted to have included as evidence such information. In addition, ALPA requested that an aviation psychologist be called to testify regarding the human factors aspects of altimeter misreads. These requests were denied. Since the Board did not deem our request applicable to the investigation, we are now providing the Board with those references which specifically speak to the subject of altimeter misreading.

We also refer the Board to a book, Aviation Psychology by N. Bond, G. Bryan, J. Rigney, and N. Warren, University of Southern California, in a study by Fitts and Jones at the Aeromedical Laboratory on instrument misreading, stated that misreading the altimeter by 1,000 feet was the most common single error.

We will never know exactly why the Captain did not detect the 1,000 foot misread, however, this is where the area of human factors must be examined. Captain Reeves made the following remarks as noted on the complete CVR. During his departure from Charleston, South Carolina, he said the following five statements: "Okay, let's go to Charlotte." "Go to Chicago, and to McCoy and rest." "That's what I need, rest, I don't need all this damn flying."

"Boy, you know if you fly real hard for about twenty five hours, you can see why they've got that thirty in seven." "Well, this is actually a decent trip except that getting up early in the morning."

Dr. Kenneth G. Bergin, in his paper entitled "The Effects of Fatigue" described fatigue as "a progressive decline in man's ability to carry out his appointed task which may become apparent through deterioration in the quality of work, lack of enthusiasm, inaccuracy, lassitude, ennui, disinterestedness, a falling back in achievement or some other more indefinable symptoms."

The Board in response to this information presented came up with this: The captain's remark about "needing rest," which appear in the first part of the new transcript, have been evaluated. We find the remarks subjective and uncorroborated by other evidence. We attempted to calculate the captain's physiological fatigue which the petition asserted were computed from the facts and formulas contained in Dr. Mohler's study. However, insufficient data were submitted to permit calculation. This goes on and on. The last sentence, since the captain was handling the radio communications, we believe this evidence supports a conclusion that the captain was not suffering significantly from fatigue induced by a heavy flying schedule.

With regard to the possibility that the first officer misread his altimeter because of inadequate or poor design features of the altimeter, we believe that the weight of the evidence does not support a conclusion to that effect and it goes on to discuss the FAA's own study on altimeter misreads.

There have been other drum-pointer altimeter related accidents. Captain Leppard mentioned a few.

In addition to his there's an American Electra at LaGuardia that hit the dike in the late 1950's, the American 707 and the Alitalia DC-9 at Palermo, Italy. As a matter of fact almost every DC-9, 10 to 30 series produced, except these ordered by Delta Airlines, came from the factory with drum-pointer altimeters installed. The FAA in 1972, conducted their own study revealing the 1000 foot misread problem associated with the drum-pointer altimeter. The U.S. Air Force in 1959, said drum pointer altimeter was an unacceptable flight instrument, yet the FAA continues to certify it and the NTSB condones the operation with these altimetry systems - obviously, as a result of the misanalyzation of the inflight recorded data applicable to these two accidents.

I would like to take just a brief second to show you some pictures of altimeters, if I may.

The first altimeter displayed is the rather antiquated by nature, but well known three pointer altimeter. This is the kind that Delta has on their aircraft, the DC-9's. The largest scale altimeter reads hundreds of feet. The smallest pointer, which is hidden behind the black tail of the large one reads in thousands of feet. And the smallest pointer on the inside scale is in 10,000 foot increments. There's a United 727 right now that rests at the bottom of Lake Michigan about 30 miles from touchdown. It isn't sure, but it's a possibility it was a 10,000 foot altimeter misread.

We advanced to the drum-pointer altimeter. As you will notice, this altimeter has one pointer which rotates in a clock-wise direction when climbing and a counterclock-wise direction when descending around the outer side of the scale, it reads in 100 foot increments. For hundreds of feet, pardon me, with 20 foot increments. The drum just to the right of the center where the cross hatched area and the pointer is, is the 1,000 foot drum. Some of the poor design characteristics of this altimeter is that number one, the hundred foot needle as it rotates through approximately a 20 or 30 degree portion will block on the right-hand side a part of the 1,000 foot drum. Also, as the aircraft descends, the drum ascends, the 1,000 foot drum. It rotates in a direction opposite to the flight path of the aircraft. And now, one of the latest, and the easiest to read and probably almost unmisreadable type altimeter is the counter drum-pointer. You will notice the single pointer that rotates around the outside of the instrument giving us 100 foot increments. This is repeated in the counters in the center. There's no doubt that airplane is at 39,300 feet. There would be no doubt when the airplane was at 100 feet.

To continue, on July 25, 1978, a North Central airlines Convair 580 crashed shortly after take-off, when the number one engine auto-feathered during rotation. The weather was indefinite 100 foot ceiling sky obscured, his visibility one half mile and fog.

Again the crew was blamed for not being able to control the aircraft and follow procedures. Examination of the wreckage revealed that the rudder would not fully deflect to the right. The NTSB CVR shortly after lift off had a comment attributed to the captain, it said: "Yes, sir, we're turning to the *" what was really said was "Can't stop it from turning to the left". Subse-

quently, the NTSB attributed the following statement to an unidentified cockpit crew member. They were never permitted to hear the CVR, or assist in its transcription. A request for the admission of corrections was sent to the investigator in charge of the NTSB. The response in writing, was that the CVR group had had an ALPA representative participate in the original transcription, therefore, no additional comments would be allowed as a result of the NTSB CVR transcript, the investigation proceeded along the lines of pilot error. The following questions were never asked by the FAA or NTSB. Why would an experienced crew attempt to fly VFR around the field with an engine out when they were already in the clouds, and the ILS was straight ahead, with only a procedure turn needed for a successful return to the airport? And second, why was the restricted rudder travel noted but not accounted for? Oddly enough, a test CV-580 of North Central's was also found to have restricted rudder travel. This aircraft, when flown on one engine was found incapable of climb performance below 108 knots of IAS, as a matter of fact, it stalled without explanation. The highest recorded airspeed on the flight data recorder of the accident aircraft was 111 knots, obvio[illegible] control of the aircraft was impossible. This information was always av[illegible], but was not searched for until the NTSB had issued their final report, bas[illegible] on an investigation, misguided by improper analyzation of inflight data, notably the CVR and FDR.

On November 12, 1975, an Eastern Airline 727 landed short of the runway at the Raleigh Durham. The flight data recorder trace produced by the NTSB showed the altitude at impact to be 475 feet MSL. The actual altitude at the accident site was 424 MSL. The flight recorder showed that the accident did not happen. Wrong again, we had the wreckage to substantiate the fact that the accident had occurred. Again, the FAA and NTSB conducted their investigation based on erroneous flight and cockpit voice recorder data. An independent readout of the flight data recorder revealed that the recorder had a malfunction resulting in an altitude error of 1[illegible] feet in altitude and a five knot airspeed error. Additionally, the c[illegible] faulted for not making proper altitude callouts during the approac[illegible] However, the CVR eventually revealed that not only were all the callouts made, but two additional altitude and one airspeed all not required were made by the crew during the approach.

Probably the most flagrant misinterpretation of the present day FDR and CVR data was during the NTSB's investigation of the PSA-Cessna 172 mid-air

collision over San Diego on September 25, 1978. It all boiled down to the NTSB and the FAA agreeing that the crew of the PSA had sighted the Cessna 172 and therefore, the horribly inadequate and totally antiquated see and avoid concept of traffic separation applied. It doesn't take an aeronautical genius to read the ATC and CVR transcripts to determine that the PSA crew never saw the Cessna which they hit. As a matter of fact, a comment by the captain during the latter stages of the flight, should have led the NTSB and certainly the FAA to discover that an additional Cessna was involved. Not until last week after exhaustive examination of two year old data did ALPA discover the phantom Cessna. As usual the FAA and NTSB both had this CVR, FDR and D-log radar data since the field investigation was completed, and the NTSB report issues.

In August of 1980, the FAA issued an NPRM seeking unlimited access to the flight data and cockpit voice recorders on all air carrier aircraft. This proposal is not only ridiculous, but borders on being absurd. First of all how could the FAA expect to establish a human factors data base by using only part of the factors affecting a flight crew's performance. Where and when would the aspects and effect of ATC, weather, aircraft performance, aircraft systems, structures, and operations, enter into the data base establishment. I would maintain that even if the FAA were to accurately analyze CVR and FDR data, which is doubtful, that to properly establish a human factors data base, the FAA would have to conduct a complete accident type investigation for each recorder examined. This is impossible. The FAA doesn't possess any equipment to perform either FDR, DFDR, or CVR readouts. The FAA doesn't have any employees qualified to perform these readouts. The NTSB has only one person presently qualified to read out digital flight data recorders, and only one person qualified to use the CVR readout equipment. Based on the NTSB and FAA's track record of misinterpretation acquired in flight data, I doubt that any conclusions drawn would be of value to the aviation community, as a matter of fact, they would most likely be detrimental. Let's face it, the FAA's proposal is physically impossible to implement due to their own limitations.

Now that I have presented a rather negative view by ALPA of the use of recorders in flight data, the question arises, how do we acquire valid data for human factors studies. First of all, the present day recorders were not designed for, nor are they capable of producing quick access and valid statistical data. Therefore, the data must come from other sources. Such as the

pilot solicited survey, cockpit observation by qualified personnel. By this I mean observers who are human factors oriented and trained, not air carrier inspectors who are barely qualified in the equipment on which they are observing. Solicitation of information from ALPA technical committees, manufacturers and aviation experts such as NASA and the airlines themselves. Expansion of the ASRS program, where else can we get unsolicited factual soul-baring information regarding the human factors involved in the air traffic system, and the flight crew operations. And last but not least re-examination of past accidents where pilot error was accepted as the cause, but the question why, was never asked.

Thank you.

CAPTAIN PRYDE: Ladies and gentlemen, our next speaker is Captain Bob Smith, who will address fatigue, workload and stress.

MR. SMITH: Thank you, Gerry. Good afternoon, ladies and gentlemen. The subject has already been addressed slightly this morning, and I must admit that being up here right now and talking about this particular subject is somewhat nostalgic for me. The Transportation Systems Center is sort of a stone's throw from MIT here, and those of you who know MIT at all understand that it's considered to be sort of a pressure cooker or a very difficult place for undergraduate students to get through.

Since it's my alma mater, then discussing workload, fatigue and stress in that order are very appropriate in view of being here today. Anybody studying or even just reading casually the subject of fatigue, workload and stress knows really what a wide subject we're attempting to deal with. In fact, the so-called experts cannot even agree on standardized definitions of what these concepts are supposed to mean. I am just simply an airplane driver, and to me fatigue really is just a general feeling of decreased awareness, slowed judgment, possibly an awareness that my skill of manipulating the airplane is just a little bit less than it could be on a good day, maybe drowsiness, inability maybe to handle unexpected demands.

I know I am a little bit slow. For those of you who just want to get a feel for what that would be like just imagine yourselves spending a day, let's say Saturday, around the house, an ordinary day, raking the leaves or whatever it happens to be; then trying to get a nap after supper sometime but you can't sleep because the kids are watching TV or whatever. And then you are forced to go out and work a night shift between twelve and six o'clock, and you are

on your way home, driving home in a car. You can just imagine just exactly how you would feel, what your state would be at that time. And quite often, that's that type of situation to which an airline pilot is exposed. To him that is fatigue.

Workload to us really means the task demands to which we areput. It means what do we have to deal with. We have to deal with handling the airplane. We have to deal with ATC instructions. We have to deal with weather. We have to deal with possible company changes to our flight plans or whatever. Maybe there's a passenger in the back who is causing the flight attendant's a little bit of problems.

Basically, these are tasks demands that we have to deal with mentally and physically. To us, that is workload. Stress, probably that is the most general term and the most indefinite term that was on the agenda for today. But the truth of the matter is that that basically is just an addition or the cumulative effect of things like fatigue and workload and all the other external stresses which each and every one of us is put to every day.

I believe Dr. Alkov would probably agree with that statement. In other words, there are a number of stresses that add up, that put us in a position where we don't handle things just as well as we possibly could under better conditions.

The effects? The effects of all these things really are just decreased performance, possibly human error, only possibly, and then of course, possibly there are a number of combination of circumstances then we are talking about possibly an accident.

Now, this is a very simplistic view that I stated, but the truth of the matter is that this is the one that all the safety personnel really are interested in; and when we discuss fatigue, workload and stress in articles that go out to crews and so on, this is the way in which it is put.

Now, why would I do this to basically a scientific audience? Well, the reason is that you can contrast that view with the view of fatigue and workload that exist in the literature today. If anyone was to review that literature, you would discover a number of different definitions of these concepts. These definitions really being ways in which these particular concepts are measured.

In 1976, I believe it was, NASA did a literature review and analysis of all the criteria which were used to measure fatigue and workload. Basically, what they came up with was about two different -- two dozen reference for each concept. That makes it very difficult for real world application or generalized utility.

Now, quite obviously, the scientific community has to closely control their experimentation. Obviously, a scientist would be criticized very highly if in fact he did not control all the factors that went into his experiment. But the truth of the matter is now that we have to attempt to get out of what I would call a rut and look at the real world applications or testing or measurement of fatigue and workload.

I don't want to suggest that the past scientific work on fatigue, for example, is not applicable. Circadian desynchronosis is a well-established phenomena, and yet the fact is that most imposed rulemaking on flight-time and duty-time regulations that was published last year, I believe, the one that is previous to the one that is now current, did not in any way, shape or form take into account circadian dysynchronosis.

For those of you who may not be familiar with the term, basically it just means that your internal bodily functions get messed up because you crossed time zones. It is a well-established principle, but yet the regulatory process has not been able to take this scientific information into account. Basically, what they rely on is a compromise solution between those parties who comment to the notice of proposed rulemaking process.

There is one example of a technique that's more real world oriented with respect to fatigue, and that was a paper published by Dr. Mohler in 1976 while he was with the FAA. Basically, what he did was he looked at such factors as flight time, duty time, number of landings during the duty period, amount of rest a crew got before they flew, and the number of time zone changes in which the airplane crossed. He combined all these into a single equation and came up with one number, that number being an index of fatigue.

Now, I am not going to comment upon how scientifically accurate that particular formula was nor whether, in fact, it is in fact verifiable; but the truth of the matter is that Dr. Mohler, while with the FAA, came up with this technique which addresses real world problems, and yet there was no attempt at any time to verify its application.

Basically, we really do require now a multi-factored approach to the problem. It's no longer sufficient to look at single causes. Similar to this sort of real world approach to the assessment of fatigue would be full scale simulation to determine workload affects. In other words, coordination of eye-hand movements or the amount of transmissions a crew makes over the year or the number that they receive or the number of switch positions that are made in any given period of time are really not accurate means of assessing the workload that goes on in that cockpit.

The only way to handle that today is full scale -- at least the only way we know today to handle that particular situation is full scale simulation. There is one other source of information with respect to fatigue and workload which really has not been utilized, and of course it has in fact been addressed here in part today already. A past transport accident data has not developed a resource to use to address to this particular question.

Basically, we are required to start from scratch. Right now we must decide what questions we want answered with respect to fatigue and workload in the future so that we can ask those questions right now; and if in fact and if and when an accident occurs, we can record that information and then come back to it at a future date to determine what the correlation is between this type of information we are gathering and the circumstance of the accident.

In summary, all I would like to say is that I think it's time that we stop looking at the trees, we step back a little bit, and we look at the forest. We do have techniques whether it be multifactor techniques in analysis or whether it be full scale simulation. We do have these techniques which if applied today will get us to at least partially a solution to the problem.

It is no longer simply a case of setting up small scale, looking at very small parts of the problem. For example, just addressing the question of a subjective scale, workload scale, which basically is an old technique. They were developed back in the sixties with the Air Force.

In other words, let's not get hung up on those particular small techniques. Let's stand back a little bit and let's go and try and attempt to deal with [illegible] scientific problems in the applied real world sense. Thank you.

[illegible] Captain Mudge will now address the subject Command Cockpit Management.

CAPTAIN MUDGE: Thank you, Captain Pryde and good afternoon ladies and gentlemen.

Command decision in cockpit management have been with us since Orville and Wilbur first flipped a coin to see who'd fly the first leg.

However, for the purpose of our consideration here we shall combine both command and cockpit management under the single heading of cockpit management.

A most important first step has already been taken, we are aware of the problem as evidenced by this workshop and other meetings that have been held within the industry.

It is perhaps of some interest that I retired from some 38 years of airline flying a little over a year one. Since that time, after the ballgame was all over, I have been studying cockpit management, and learned how I should have played the game. It has been a shocking experience. The old story of too late we get smart must be changed.

The scope of the problem of course, extends throughout the aviation system and includes all those who take part in the operation of aircraft. However, by virtue of his position in the cockpit, primary attention must be placed on the cockpit manager. He is not only in a position to make a critical mistake and also to save the situation even when a mistake may have originated externally to the cockpit. It is very important that we have a strong last link. As we strengthen this link we strengthen the airline and the industry.

For many years corporate top management has recognized the leverage factor involved in their executive decisions. Today airline executives are recognizing the importance of leverage in decisions being made by their cockpit managers. With operating costs ranging from 50 cents per second to $1.50 per second it is not a difficult process to prove. It works in areas of flight safety, flight efficiency and even passenger service. Training costs relating to cockpit management can very easily be justified.

For example, we need improved command performance as a function of time by only 35/10,000 of 1 percent to pay for $1,000 worth of training and we have not even considered product improvement or, most importantly, flight safety.

Cockpit management, by our definition, is the effective direction, control and utilization of available resources to maximize flight safety flight efficiency and passenger service.

But this is not enough, we must specifically identify exactly what a cockpit manager must do, both overtly and covertly. We must go through a form of task analysis, or some similar procedure. With increasing automation within the aviation system, and particularly on the flight deck, we find we are flying less and managing more. Workload is becoming less physical and more mental. As we deal with cockpit management we must deal with such things as: Interpersonal relationships on the flight deck, assertiveness training and its control, judgment and decision making workload recognition and control cockpit discipline and self-discipline and on and on and on.

Once we have identified what he must do, it is then necessary to determine exactly the information he needs to do this in a very professional way. This permits us to better identify the specific training task to be done. Very simply, we subtract what he already knows from what he needs to know -- that is what must be trained.

It is suggested that an information bank be formed to collect all that we know about cockpit management methods. Some means would have to be devised to justify conflicting information, to translate information from specialized disciplines into the pilot vernacular, and to develop effective communications between industry sources, operators, manufacturers, pilots, and academic and research organizations.

In comparing information in the bank with that which is needed by the cockpit manager, certain deficiencies are apt to be evident. In such cases bank sources would search academic and research organizations for the needed information. If still unavailable, new research might be justified.

Thus far, our problem appears very straight forward. Not so. Teaching cockpit management is not like teaching a new hydraulic system. We are attempting to change long established habit patterns or create new thought processes. We are dealing with pilot characteristics deeply imbedded in his style as a pilot. We are dealing with attitudes and motivations. It is indeed a very tough training assignment and not generally one the typical airline training department can well handle, nor even one the guest psychologist can solve

easily by riding the jump seat for a few days and then meeting with the line pilots. It is a very tough training assignment and requires a great deal of planning and preparation.

Although we are concerning ourselves here with pilot training in cockpit management, we must also recognize the importance of human factors training for all other members of the operational team.

Cockpit management training is needed now. We should not wait for the conclusions of long term research programs, or academic studies, or even the development of an information bank. Enough is known to make great progress right now. We should establish a base program to which modifications can be applied as our knowledge grows.

Dr. John Sullivan of Suffolk University, in a recent paper suggested the need for a stronger link between the air transport industry and our colleges and universites. We strongly agree that this is necessary and would include the research organization doing relevant work as well. Not only that, we feel the time may well be coming for the establishment of an industry supported institute of flight technology. That would attract talented students and educate them for leadership positions within the industry, much as our medical, law or business schools serve their disciplines today.

After clearly identifying the training task, we must find a way to package the program so that it accomplishes its objectives and actually results in desired behavioral changes. It must be remembered that behavioral change is the end result sought. If none occur, the program has failed. It's that simple.

Since the behavioral changes we seek are difficult, it is likely that our training package will be complex. It certainly would be classed as a training system and involve all those characteristics of a true system.

We have mentioned the communication problem before. Every discipline has its own vernacular, aviation is no exception. Even though material from other disciplines is being presented, it is incumbent upon the trainer to speak the language of the pilot, not the other way around. The program that does not speak the language of the pilot will fail.

A cockpit management program must face the real world problems that concern the cockpit manager, to confront these problems requires courage on the part of the trainer, the airline and the FAA.

For example, we cannot continue to accept philosophies and policies which may be overly conservative, perhaps to protect the policymaker or for better public relations, but which do not help guide the pilot toward solutions of real world problems. One illustration most airlines, nearly all safety organizations, and even most pilots when asked, have policies of nearly complete avoidance of severe storm area. But observations of daily operations prove quite the contrary. We do fly in severe storm areas and realistic guidelines are needed.

At the time of the 727 accident at Kennedy, some 13 other aircraft representing some dozen different operating companies were doing exactly the same thing.

And so it goes, we hide behind a screen of overly conservative and unrealistic policies that cannot, or at least are not followed. As a result, the pilot must encounter very real problems with very unrealistic guidelines. If such problems are not confronted head on, the cockpit management training program will quickly lose the confidence and respect of the pilot.

Since this is a new area of training within our industry, it must be approached with an open mind. We cannot have preconceived ideas as to what format is proper and what is not. What works for systems instructions, or even recurrent may not work here as we deal more with attitude and motivations. The bottom line will be the results obtained.

An important part of any training system is the feedback which takes place from the pilots to the program. In this case, it will be particularly important because the industry needs more information and only professional pilots can give. The cockpit management program can be a vehicle for obtaining this information. This should provide a valuable source of new information for researchers and program developers.

Initially there would appear to be three phases to the cockpit management training for pilots, at least as far as airline pilots are concerned. First priority, first officers upgrading to captain. Second priority, existing captains. Third, introduction into basic flight programs first, at the under-

graduate level of colleges offering flight programs, then expanded to all basic flight programs. Reaching the pilot when basic habit patterns are being formed is most important.

In summary, as we work our way into cockpit management training, let us keep in mind the leverage factor involved. Substantial training costs can be justified that cockpit management training is different than the usual training we give pilots. That it requires a system approach. That the nature of cockpit workloads are changing. That we must center our attention on behavioral change. And finally, we must confront the real problems in a realistic way, and please speak our language.

Thank you.

CAPTAIN PRYDE: Thank you, Bob. Our next speaker is Captain Jack Howell, and Jack will address a pilot ATC environment interface.

CAPTAIN HOWELL: Thank you, Captain Pryde. My comments this afternoon will deal with the requirements now and in the future with respect to the pilot ATC/environment interface.

Let me start by saying that in a recent meeting I was asked by the attendees to list mistakes that had been made in a certain project; and having perfect hindsight as each of us has, I enumerated six items or so with which most of the people agreed. Buoyed by that success, I am going to try the same thing with you today. Only it is a little more difficult because instead of looking back at mistakes in the past I am going to try to enumerate for you some requirements for the future systems; and these requirements are based on the assessments made by the airline pilots.

Let me also make it very clear that I'm fully aware that what I list as a requirement will not necessarily be regarded as such by each and every one of you. So to keep your attention at least past the introduction part, let me say I am going to list these and call them concerns; and these are concerns held by the pilot group with respect to the pilot ATC/environment interface for now and in the future.

This list of concerns has evolved from discussions that I have had with line pilots, the ALPA technical committees and with assorted ALPA safety representatives who are vitally concerned about where the industry is headed. These concerns are associated with three basic characteristics which are not at all comforting.

The first one is the stress of economics in airline operations. That stress is of great importance and especially so since the deregulation, and we pilots feel it just as deeply as any one of you; and we are in sympathy with every effort to minimize waste and inefficiency. But we are concerned that economic considerations when held up against minimum standards will force us all to accept some uncomfortable situations.

One note that we do take comfort in is the statement by Deputy Administrator Quentin Taylor who at the Consultative Planning Conference on January 29th of 1980 which was, you may recall, the FAA response to the new engineering and development initiative recommendations. Mr. Taylor said, and I quote, "No change to the system will be permitted to reduce safety. On the contrary, new systems or procedures will be judged on the increase in safety to be gained."

The Air Line Pilots Association will probably fall back on this statement many times in the near future, and the individual line pilot will have to be the last stop-gap measure in many uncomfortable situations.

The second characteristic that we abhor is the seemingly fragmented approach to solving specific problems. We have got to learn, we collectively as an industry have got to learn to use the systems approach in aviation problem solving; and we've got to learn to put the human in that systems analysis.

The third characteristic which pervades these concerns is what I describe as a negative attitude about progress. Now, that's not very comforting. It goes something like this: If as many things go wrong or go sour -- not wrong -- go sour in the next decade as have gone sour in the last decade, then the job of an airline pilot will certainly be more challenging.

Well, those are the three characteristics which I see, and let me enumerate the list of concerns. I've got eleven of them. I'll try to elaborate on each one individually to give you some idea of what I mean by a one word description.

The first one I call is density. Now, I could show you some charts on fleet sizes; but I wouldn't really be certain of the absolute numbers. But I think we would all agree that the civil air fleet size is on the increase. And one estimate, one source that I've seen, estimates that now it's in the area of 200,000; and by 1991, it might be as much as 300,000. That's a pretty substantial growth. But again don't hold my feet to the fire with the numbers argument. Let it just stand by saying that it looks like the number of airplanes is on the rise.

The same thing is true for IFR operations which one source says will increase by 1990 some 58 percent. Hold that up against the probability that there will be no new commercial jet airports. What there will be probably is new runways at existing airports. And what we find is that we are going to have higher densities at the airports across the country. Our never ending quest for efficiency in capacity will mean that there is less room for error in the air transportation system. And that's the bottom line for my density argument. Less room for error.

Secondly, the drive for greater capacity for many means reduced longitudinal and lateral separation; but with no system improvements or adequate backups to the existing system nor collision avoidance systems, the pilot group in all probability will not accept reduced longitudinal nor lateral separations. A bold-face statement.

Item three I have here I call my deck-top data gathering. Most of the pilots feel that we are not asked well enough in advance of designs which impact the ATC or flying environment. Designers fix in concrete the environment of the crew. Mr. Miller said it very well this morning. Don't ask the pilot to design the cockpit; but for heaven's sake, at least let him evaluate it. We feel we are being asked too late. I'm referring not to cockpit design at this point but to ATC systems problems and their solutions.

All too often, the search for a solution to an ATC problem starts and ends in an ATC facility. Let me tell you that we invite you and we urge you to come see it from our viewpoint. Come in the cockpit with us. I know that leads to a problem of displacement, scheduling, etc., and somewhat inefficient; but give it a shot. You might see things from a different perspective.

Item four, noise abatement procedures. The proliferation of weird noise abatement procedures really has us confounded. I allude to such things as idle climbs, manuevering arrivals and circuitous routings near airports. We've got to come to grips with the real source of the problem because we've gone about as far as we can go with the airplane and procedures.

Item five, minimums becoming standards. Somewhat a philosophical argument, but we see a trend whereby the industry is moving toward just that the acceptance of minimums as standards. The illustration that I choose, I know one aircraft model the rule book says (the flight manual says) for G limits

minus 1.0 to plus 2.5 flaps up; but a crew had the opportunity to put the airplane to a 5G test or better, and it landed.

Many of the pilots feel that the next generation aircraft may not be able to survive such an encounter because of the tendency to design the minimums.

Item six, automation without sufficient monitoring. Very simply stated, we are going to be required to make automated landings in zero zero conditions and we may be looking at the same thing the auto-pilot is doing rather than an independent source which would provide us the opportunity to make a timely assessment of the actual performance of the aircraft. Automation without monitoring is certainly one of the greatest concerns that we have.

Item seven, the keyboard. Oh boy, the keyboard. When I speak of the keyboard as the input device for any of the flight management systems or navigation systems which are coming in the next generation aircraft. My limited experience with Omega has led me to classify all captains -- and incidentally, to set the record straight, I am a first officer and not a capatin -- but all captains can be classified into two categories, the leaners and the machos.

Now, the leaners are the guys who got to get way down in under the glare shield to tap in the inputs to the Omega system because their arms aren't long enough if they're leaning back. The machos are the guys who look at you and very reluctantly reach in their pocket and pull out their glasses and they put them way down on their nose and do the input that way. But the point is for both groups there is a substantial amount of head-down time. When you're thinking of the keyboard as in input device, remember it has serious limitations from a human factors point of view.

So the bottom line is let's not just talk about voice input for the controller, let's think about voice input technology for the air crew.

Item eight, losing the big picture, I call it. Losing the big picture means that each and every airline pilot flying in the system uses the audible RT to develop in his mind an idea of what's going on around him with respect to the airport and surrounding traffic. If somehow we evolve to a system whereby the signals are coming from the ground and are displayed visually only and limited to only presenting information about his own ship, we would lose that big picture that we strive so very hard to get. That, of course, reflects back to the early argument on automation without monitoring capability.

Item nine I call manual reversion when all the black boxes are gone. With respect to that, I am not talking about flying the airplane but managing the aircraft in the system. It leads to the bottom line that what we need is an independent collision avoidance system to save us when we have the computer outages that are so much in the news today.

Item ten, I have it listed as inadequate training. Well, that's probably an unfair statement. Not inadequate training but maybe incomplete is better. We already heard this argument this morning that the air crew really learns about 25 percent, and only 25 percent, of the capabilities of the system on board as he comes through the programs. This is one area that can be improved tremendously especially for new systems.

Last of all but perhaps one of the most important from a human factors viewpoint is developing pilot confidence in any new system that is proposed. Without the pilot confidence, you are not going to have the guy shooting the minimums, you're not going to have him accepting reduced separations. And how do we do that? Probably there can be some very constructive educational programs developed with each and every improvement in the ATC system to bring about pilot confidence before the system is turned on and made a standard.

Those are the concerns, sort of a shopping list approach, certainly brief; but I think they are the kinds of things that are really grating on the conscience of the airline pilot community. We look forward to working with you in trying to get solutions to some of these concerns. As a final reminder, you may not want to get the help and the input from us directly; but its's probably a lot better to do it that way than to read it in a newspaper after it's been filtered through a journalist. Thank you very much.

CAPTAIN PRYDE: Thank you, Jack. Our next subject, I will introduce John O'Brien and he is going to handle the certification problems and solutions.

MR. O'BRIEN: Thank you, Gerry. I want to say a little bit about the certification process, that is the FAA certification process as it applies in a general sense.

The certification process as it presently exists does not have any well-planned consideration of human performance. The process is based on regulations, advisory circulars, and FAA policy and guideline documentation which is lacking on the subject of human factors or human performance.

There is not one readily identifiable point in the certification process where it would be proper to place a significant human factors or human performance project. Instead, there is a need for more emphasis on human performance throughout the process from initial design, fabrication, simulation through flight verification.

Our concern lies not only with the design of aircraft systems or components but with the resultant aircraft performance which is provided by these systems, the data that provided by these systems and the crew, how much data is given to the crew, and how the data is presented and what is expected of a flight crew upon reception of this data under normal and emergency conditions.

When you examine the current regulations and the FAA guidance material, the lack of consideration of human performance startling by its absence. We don't mean to infer that there is not actual consideration of human performance by FAA or the manufacturers because there is in some specific areas. The problem is that it is not a coordinated nor a regulatory required effort.

There has been in many areas some discussion over the past several months over the issue of crew complement. Our concern on the certification process in some people's minds is limited to the issue of crew complement. This is not true. I could go on for an hour or more on several issues from contaminated runways to the new digital avionics to you name it. We have several concerns in the certification process. But what I'd like to do is give you an example of why we have a concern for the issue of crew complement in the certification process.

It is because we feel that this is a proper area to address the subject. Prior to 1965, all aircraft over 80,000 pounds were required to have a crew complement of three. This requirement was established by a Presidental Commission after a series of accidents and incidents and disagreements within the industry. The scenario I want to go through for you is not intended to attack or take issue with any particular manufacturer or any particular aircraft, but it is scenario that has been documented through a freedom of information request that we undertook.

In 1963, the manufacturer notified the FAA that it wished to discuss cockpit evaluation of two-man crew in the Preliminary Type Certification Board Meeting. The aircraft was envisioned to be less than 80,000 pounds.

During the Preliminary Type Certification Board Meeting, the manufacturer submitted to the FAA a detailed outline of the cockpit design. The FAA notified the manufacturer that "further evaluation of the cockpit design will be required, and the FAA would advise the manufacturer at the earliest moment of the findings."

In July, 1963, a meeting between the manufacturer and the FAA was held, the purpose of which was to familiarize the FAA Washington representatives with the background leading up to the design of the present cockpit configuration. The following appears in an FAA report of that meeting:

"As a result of the evaluation of the cockpit during this visit and the design concepts which the manufacturer had employed in all of the aircraft systems, we are convinced that the aircraft can be safely operated, even in high density traffic areas, with a crew of two pilots."

To substantiate this position regarding the crew requirements for the aircraft information will be supplied in a submission of additional material by the manufacturer.

In a letter to the FAA, the manufacturer provided the information requested and closed their letter with the following sentence: "We would appreciate your confirmation that the airplane will be certificated, subject to flight evaluation" -- I want to emphasis that point -- "for operation of two - a pilot and co-pilot."

On September 6, 1963, the FAA, having reviewed the documentation supplied by the manufacturer, distributed an internal document which stated under "Findings" the following: "In consideration of the foregoing, the aircraft has been found to comply with all criteria, subject to flight evaluation, for operation of a crew consisting of a pilot and a co-pilot."

In a September 24, 1963, letter to the manufacturer from the FAA, the following statement is made: "It has been found as a result of our evaluation that the aircraft is eligible, subject to flight evaluation, for operating as a transport category aircraft for a crew consisting of a pilot and a co-pilot."

Now, all preceeding correspondence has dealt with an aircraft which was designed for a minimum gross takeoff weight of 77,000 pounds, under the 80,000 pound rule. No problem with crew compliment.

On September 24, 1963, the manufacturer petitioned the FAA for an exemption to several Air Regulations which require a third flight crew-member for all airplanes certificated for more than 80,000 pounds. The manufacturer's letter goes on to state: "We are discussing increased ranges of the aircraft with several customers and now, of course, this requires additional fuel which means maximum takeoff weights in excess of 80,000 pounds."

"We believe granting this request will be in the public interest because it will help the aircraft to be a success which is important and vital to our nation in many ways. It will bring strength to the civil aircraft manufacturing industry of this country and to its thousands of suppliers. It will provide, directly and indirectly across the nation, an average of 73,000 jobs for an eight-year period. It will help maintain the U.S. position as the foremost builder of transport aircraft for the next ten or more years, and its potential effect on the balance of trade could amount to as much as two billion dollars. The airplane will bring jet service to communities now being served by propeller driven equipment." Obviously, all very worthwhile factors to be considered.

In a February 18, 1964, letter from the manufacturer to FAA, provided large colored photographs of the cockpit as well as two drawings of the cockpit. This was to assist in the crew complement decision.

In a February 25, 1964, letter to the manufacturer, it was noted that these colored photographs and drawings "would be very helpful in our evaluation of flight crew requirements for this aircraft."

In a March 16, 1964, FAA letter to the manufacturer, the following quote appeared: "We have concluded that this aircraft may be safely operated in the air carrier service by a properly trained crew of two pilots."

In a March 24, 1964, FAA internal memo, the problem of not granting an exemption to the 80,000 pound rule was described as a major one obstructing the sales efforts in competition with foreign manufactured aircraft. The manufacturer goes on to state, "manufacturing personnel report that foreign manufactured aircraft sales are being made with a guarantee that the airplane will be certificated to be operated with a crew of two at weights above 80,000 pounds. In order to enable the U.S. to compete in the sales race, the manufacturer has requested some assurance in writing from FAA to the effect that

they will be able to deliver the aircraft with airworthiness certificates with a crew of two at weights in excess of 80,000 pounds."

In a June 23, 1964, letter from FAA to the manufacturer, the following statements appeared: "The minimum flight crew for the aircraft will be determined in accordance with the provisions of CAR 4b and the export certificate for the aircraft will be based on compliance with CAR 4b."

On April 27, 1964, the FAA issued a Notice of Proposed Rulemaking which would establish new regulatory requirements for the determination of crew complement. On May 28, 1965, the regulatory criteria presently contained in FAR 25.1523 became effective along with Appendix D to this part. This contains the criteria for determination of crew complement.

In the May 27, 1965, minutes of the Preflight Type Certificate Board meeting, the manufacturer was informed that the two-men cockpit design concept would comply with the new regulations. The minutes went on to state that the aircraft cockpit, as presented to the FAA, was suitable for a two-man crew pending flight test evaluation.

The minutes of a October 28, 1965, Interim Type Certificate Board meeting contain the following statements: "The manufacturer was informed that the two-men cockpit design concept would comply with the regulations. The FAA review team determined that the aircraft cockpit as presented to them was suitable for two-man operation pending flight test evaluation. During the test program, FAA had been evaluating the cockpit and the cockpit arrangement appears satisfactory. However, this item will remain open until the completion of the flight test program..."

In the minutes of a November 1, 1965 Type Certificate Review Team Report, the following statement appears: "Under the title '80,000 Pound Rule'. It is evident that this aircraft will be the first aircraft over 80,000 pounds (gross airborne weight permitted -- 85,600 pounds) to be operated in air carrier service by a flight crew of two. Final determination will be made upon the completion of the flight test program."

In an April 6, 1967, internal memo titled, "History of the Certification for Minimum Flight Crew and Flight Engineer Requirement", the following statement appears: "The aircraft was certificated on November 23, 1965, and the criteria set forth in Appendix C of FAR 25 was essentially that used or the

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aircraft for airworthiness approval. The 80,000 pound rule was revised prior to the certification of the aircraft and therefore is not considered a factor in the operations approval of the airplane."

In several of the letters, internal documents, and reports mentioned in this chronology, the FAA states that the aircraft will be certificated for two men. However, this determination will be made pending further flight evaluation. That statement is made several times. As can be seen through a review of this documentation, no record of flight evaluation to support this determination is available. ALPA has been provided a signed affidavit from the FAA Western Region that all available documentation on this subject has been provided to ALPA in response to our FOIA request.

Now, why did I go through that lengthy dissertation? Well, what concerns us the most about this scenario is that it set a precedent for certification of air transport category aircraft with a crew complement of two which was based on an inadequate consideration of pertinent human factors considerations.

So, what can be done about this? We have written on more than one occasion to the FAA and to the manufacturers and suggested that an adequate examination of human factors during the *aircraft certification process* could answer to our statisfaction and should answer to the FAA satisfaction the issue of crew complement.

Present regulations, FAR 25.1523, is adequate. This regulation describes how the crew complement issue should be resolved. Appendix D to this regulation reads like apple pie and motherhood. It contains all of the necessary ingredients that should be examined. This sounds fine up to this point, but the process breaks down when you get to the engineering flight test guide. This is an internal FAA document. This document describes the testing procedures and the data that must be submitted by the manufacturer to show compliance with the regulations. The regulation is fine. Appendix D is fine. But there is no criteria in the engineering flight test guide by which the manufacturer can use to show compliance with the regulation.

We would like to insert in the engineering flight test guide a series of tests and data analysis requirements to answer the crew complement issue. As a matter of fact, I'd like to read a recommendation concerning aircraft cockpit design.

We recommend essentially the same certification philosophy which is applied to other aircraft components and systems. A full and comprehensive testing program covering normal through worst case conditions should be employed to establish a sufficient safety factor for all anticipated operations. For cockpit design and crew complement, the certification plan should require a series of flight tests to validate other test results and also full simulation testing through which extensive worst case problems can be assessed. Full mission simulation now permits the use of available and accepted technology to test cockpit designs under adverse condition without risk to the crew and aircraft. The use of full mission simulation in certification is based on the same logic that the FAA uses in advocating simulation in line oriented flight training programs.

Our recommendation to use full mission simulation testing with in-flight validation also is consistent with the interest of obtaining the safest possible aircraft in accordance with Section 603 of the Federal Aviation Act which direct the FAA to make or require the applicant to make such tests during manufacturing and upon completion as the administrator deems reasonable and necessary in the interest of safety. The recommended plan could be based on a set of scenarios which accurately reflect conditions expected to be found in anticipated operation of the aircraft. The scenarios will vary task loading from normal to high levels through the introduction of degradated system operation, malfunctions, total failures, partial failures, crew incapacitation, company requirements, paper work, cabin and dispatch maintenance, communications, etc., ATC interactions and weather changes, affects of fatigue on crew, performance.

All tasks are based on incident/accident or service difficulty report data, published aircraft procedures and line experience for similar type aircraft. These taskload changes will introduce variations in crew workload which will allow a proper evaluation of the workload to better determine the capability of the crew to safely operate the aircraft.

Our recommendation also purposes a comprehensive evaluation plan. As you may be aware from the FAA sponsored MIT workload scale project, careful evaluation is vital. We will suggest prior to performing any testing that evaluators be extensively trained in aircraft procedures particularly to the aircraft being certificated. Detail data, recording forms for determining

test crew errors will be required as crew errors and omissions from the basis of workload assessment. As errors may not be immediately recognized, all scenario tests should be videotaped using multiple cockpit cameras for later evaluation review.

We would also recommend that test data be made available to researchers and other interested parties and techniques such as the MIT workload scale should be considered by tryouts so that the maximum use can be made of collected information to improve future workload certification technology. The collected data should be reviewed to determine systematic errors by test crews. Such errors would identify periods of tasks, workload shedding and in turn overload and near overload levels of workload.

Should even a single overload occur, there is a deficiency in the cockpit design which requires correction as the conditions causing the overload could occur in an actual operation with unfavorable consequences to passenger and crew. Design problems can be rectified by re-allocation of crew duties, addition of a crew member, hardware/system information modification or assignment of operating restrictions and limitations.

Now, the important point. The final determination of the acceptable cockpit design, workload level and crew complement will be based on the best judgment of the FAA Type Certification Board. We recommend that this portion of the certification procedures be open to interested parties to provide input to the board, the FAA Type Certification Board, in making their final decisions.

Also, the Board must carefully consider the cockpit configuration of the test aircraft to ensure that the test is conducted with the standard equipment and instrumentations and not optional features that may be ordered by some airlines.

Basically, that's it as far as the crew complement issue is concerned. We would like to see it solved in the aircraft certification process, not as it is currently being done.

CAPTAIN PRYDE: Thank you, John. I have been informed that the coffee is ready, and we will take a fifteen minute coffee break. We have one more presentation by Bill Edmunds on the ASRS program. We'll do it when we come back from coffee.

(Recess taken.)

CAPTAIN PRYDE: Bill has a presentation on the aviation safety reporting system.

MR. EDMUNDS: Obviously, it goes without saying that all of us here at this workshop today are interested in addressing the human factors problems that we see in aviation today. We touched on a lot of them today in this panel. A lot were looked at this morning. I think that what the human factors problems really boil down to ultimately when everything is said and done is investigating and addressing those factors which affect the human performance of personnel, that is both pilots and air traffic controllers in today's aviation system.

I am talking about the man-man relationships as well as the man-machine interface. I'd like to talk today about the Aviation Safety Reporting System as administered by the National Aeronautics and Space Administration. This ASRS program receives information and perceptions about shortcomings and failures within our aviation system from the people who operate it and are most intimately involved in it day to day.

The ASRS program was already discussed in some aspects this morning, and I won't really touch on those again. I would like however to emphasis some of the other aspects of the ASRS program. The ASRS program came about after the accident of TWA flight 514 during its landing approach into Washington airport. During the investigation phase of the accident, it appeared that there was some information available to crews on other airlines concerning approach procedures. The crew on this particular TWA aircraft was not aware of the safety information. They fell into a trap that the other airline crews probably were aware of would not have happened to them.

And out of that grew the Aviation Safety Reporting System which is basically an exchange of safety information among the operators of the aviation system. The ASRS program is laid out in Advisory Circular 00-46 of which there are three versions, 00-46, 46A, and 46B. The difference between 46 and 46A is merely one of administration. That is who administered the program. It changed from FAA hands essentially to NASA hands.

The differences between 00-46A and 00-46B were much more substantial in nature and involved somewhat basic changes to the program. We mentioned

those this morning, changes in the waiver of disciplinary action being available only one time and some other changes in the way the reports are handled. If we look at the information that we get out of the ASRS program, we have three basic facets of that. We receive alert bulletins or actually the FAA receives alert bulletins when the NASA or BATTELLE contract people analyze reports, they quickly pick up trends of problems areas. If the trend is deemed serious, they will initiate and send to the FAA and alert bulletin for corrective action.

Quarterly reports generally provide an outline of the types of reports that have been received at the ASRS within a given period of time, and will usually contain a special study of some of the information contained therein. We have also seen a number of special studies that have appeared outside of quarterly reports. The most recent of which was a study on fatigue factors in aviation that appeared that was done to support a NASA fatigue workshop at the end of the summer.

We are quickly coming to a critical juncture in the life of the Aviation Safety Reporting System. The memorandum of agreement between the FAA and NASA will terminate as of September, 1981, and we are wondering who will and what will become of the ASRS program, who will manage it, and where it will be going after that particular date.

We want to emphasize that the ASRS is a viable program, it is an important program, notwithstanding some of the tamperings that have gone -- occurred to it in the past. We feel that one of the great values of the Aviation Safety Reporting System is that it is an independent reporting system.

The FAA in addition to wanting and taking up programs to study human factors, human factors problems in aviation, is notwithstanding required to enforce also the Federal Aviation Regulations. The reporter perceptions in this regard are extremely important. I mention earlier that the differences between Advisory Circular 00-46 and 46A had to do mainly with the administration of the program. The FAA had been receiving reports under Advisory Circular 46, and when 46A was instituted the program was changed over to NASA as an independent manager of the program.

During the first three months that NASA was handling the program, it was perceived by the pilots as being completely independent of the FAA. They re-

ceived approximately the same number of reports that the FAA had received under essentially the same program in the past eleven months. So reporter perceptions are very important into how the ASRS program is handled.

In conclusion, in summary, I'd just like to state that the ASRS is maturing. Some people would say it even has matured as a valuable research tool. We want to emphasis that if it is to continue to provide a real time look at our aviation system the way it is now, the way it is evolving. It must be supported and maintained in its present independent status. Thank you.

CAPTAIN PRYDE: Ladies and gentlemen, that completes our formal presentation. We are all available for any questions that you might have. No questions?

MR. DAVIS: Phil Davis, OAO Corporation. I'd like to address a question to Jack Howell. One of the points you made in one of your concerns in noise abatement procedures dealt with circuitous approaches implying that these were safety hazards.

An opposite point of view was raised many months ago in an article in a Washington, DC newspaper about discussing the down-river approach to Washington National Airport, which for those of you who don't know, twists to follow the Potomac River. One of the sources quoted in the article stated that the reason that National Airport's safety record was so good was because the approach was so difficult and adrenalin was always pumping and the pilot had to concentrate.

This point of view was indirectly borne out this morning when we were discussing fatigue because the point was raised that fatigue is manifested by a lack of concentration or drowsiness when the workload is light. Implying that when the workload is high this can be overcome. So the question is: are circuitous approaches safety hazards or safety factors?

MR. HOWELL: Hazards. As you have pointed out, there may be some advantages to the circuitous approach of that procedure which involves a human. But again we go right back to where we were this morning, and the question was asked in a slightly different form. What is that optimum workload, that optimum human involvement, in the scenario which minimizes the chance of error from that human performer.

A circuitous route probably is hazardous in the sense that it generally involves encumbering ATC procedures, unnecessary RT, low altitude vectoring, etc. The goodness associated with the river approach is due to the fear.

Somewhere there is a balance probably between the circuitous route and the river approach.

I would say what we're really looking for and what I was trying to hammer at in those comments was this optimum workload thing, human involvement is where the human factors effort needs to be concentrated. Did I get anywhere close? I think Chuck Miller is going to help me.

CAPTAIN PRYDE: Mr. Miller.

MR. MILLER: As the author of that particular remark made first in the fall of 1974, perhaps I ought to make sure it doesn't get dropped where it is. I presented a slide to some people one time which said that simple logic tells you that as the hazard level increases the level of safety decreases.

In other words, if you plotted hazard level this way, and safety level this way, you have a 45 degree line theoretically. But using Washington as an example, I drew a line that said as the hazard level increases you actually get a slight increase in safety; but that's where the catch comes. It will come back up much like an angle of attack curve on a straight wing airplane where instead of being nice and round it's going to come up and all of a sudden go to hell. So what you are doing is you're making use of the person as an improvement in safety, but his margin becomes so cirtical that if he goes just a little bit farther he has no chance.

Anybody that approaches at Washington National knows exactly what I am talking about there. If everything works fine, great. But if you have to make a last minute change from one runway to another for example which I've seen done, it gets pretty hairy. The paper that initially presented this, I tried to be very careful to point out, No. 1, the break off point is severe; No. 2, if you delude yourself into trying to use that little part of the curve as I described it, you forget one thing. Complacency can set in with someone who tries to operate on that part of the curve all the time. That's the whole story as it was written in 1974.

UNKNOWN SPEAKER: I would like to make one comment on the Washington approach. I have been flying that approach for the past 18 years and it is an interesting, to say the least, approach to an airport. I think a couple of factors might be relevant as far as the gentlemen's question over here regarding whether it is an enhancement of safety or a degradation of it.

Let's look at all the things that happen with a circuitous route. If a circuitous route necessitates the aircraft being in the air for any longer than necessary, the exposure time to a midair collision is increased. That's just a plain, simple fact. Or imminent impact with terrain because of some other maybe human factors reason.

That airport also only operates from seven o'clock in the morning until ten o'clock at night. There is a large portion on the 24-hour clock that the airport is not in operation and those are during the hours at which maybe fatigue and tiredness and the level of concentration required by the pilots would be probably higher due to the problems of night flying; but they are not there because the airport does not run at night.

So I think we ought to look at that approach in a little bit different light than just a circuitous routing.

MR. PRYDE: Any further questions?

(Session two concluded.)